Susquehanna River

MARYLAND WATER SUPPLY AND DEMAND STUDY

Part I
BASIC DATA

Volume 2
SUSQUEHANNA RIVER BASIN

Prepared for
MARYLAND STATE PLANNING DEPARTMENT

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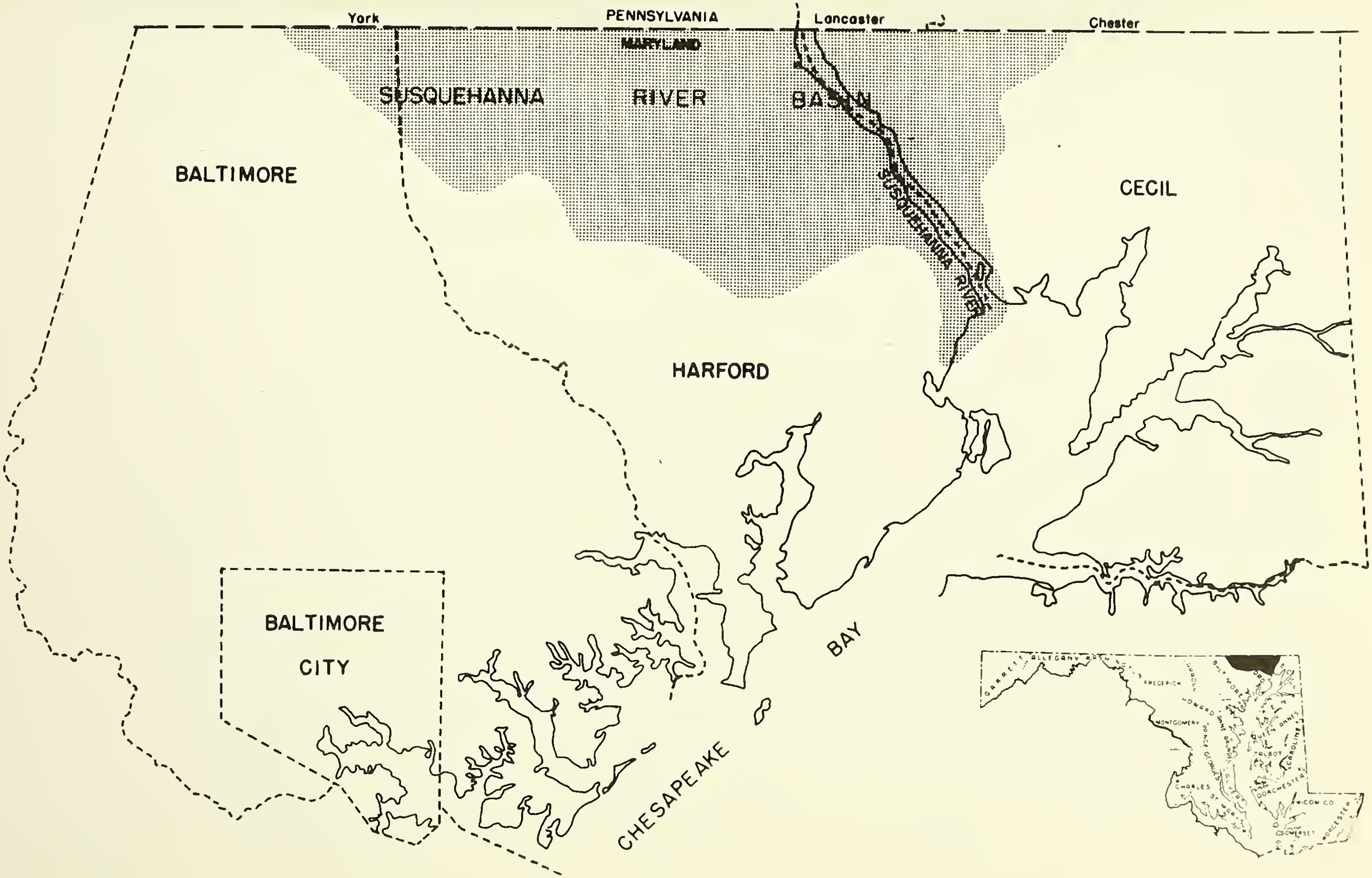

SUSQUEHANNA RIVER BASIN IN MARYLAND

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SUSQUEHANNA RIVER BASIN

GENERAL DESCRIPTION

The Susquehanna River is the largest stream on the eastern seaboard of the United States, the surface runoff averaging 24.8 billion gallons per day. The main stem of the Susquehanna is formed by the confluence of the North and West Branches at Northumberland, Pennsylvania. From its head at Northumberland, where the low-water elevation is 430 feet above mean sea level, the Susquehanna courses southerly to the mouth of the Juniata River and thence southeasterly to sea level at its own mouth at Havre de Grace, Maryland, on the Chesapeake Bay. From head to mouth, the Susquehanna has a length of about 128 miles, 112 in Pennsylvania and 16 in Maryland. The average fall of the main stem is 3.36 feet per mile. The drainage area covers approximately 27,500 square miles, of which 280 square miles lie in Maryland, 21,000 square miles in Pennsylvania and 6,270 square miles in New York (North Branch).

Physiographic Divisions

The Maryland portion of the Susquehanna River drainage basin lies mostly in the Piedmont Plateau province, but a small area lies in the Coastal Plain province. The "Fall Line," which separates the two provinces, crosses the river a short distance upstream of Havre de Grace. This line coincides roughly with the boundary between the crystalline rocks of the Piedmont Plateau and the unconsolidated Cretaceous sediments of the Coastal Plain.

Political Subdivisions

In Maryland, parts of only four counties are within the drainage basin of the Susquehanna River. Cecil County, lying to the east, and Harford County to the west are separated by the river which forms their common boundary from the Pennsylvania-Maryland line to Chesapeake Bay. The northwestern part of Cecil County drained by the Susquehanna River includes all of Election District 8 and parts of Election Districts 6, 7 and 9. The northeastern part of Harford County in the Susquehanna drainage area includes all of Election District 5 and portions of Districts 2, 3, 4 and 6. West of Harford County a portion of Election District 7 in Baltimore County lies in the Deer Creek watershed, a tributary area of the Susquehanna. A small corner of Election District 6 in Carroll County is also in the basin. Of the total drainage in Maryland, approximately 201 square miles are in Harford County, 63 square miles in Cecil County, 10 square miles in Baltimore County and five square miles in Carroll County.

Principal communities in the Maryland portion of the Susquehanna River Basin are Havre de Grace in Harford County and Port Deposit, Rising Sun and Perryville in Cecil County. The U. S. Navy operates a large training center at Bainbridge near Port Deposit. The Maryland population in the basin is about 85,000. (Total population of the Susquehanna basin is over 3 million with approximately 2.5 million in Pennsylvania and 540,000 in New York.)

Major Sub-basins in Maryland

The more important sub-basins of the Susquehanna, either wholly or partially in Maryland, are Broad, Conowingo, Octoraro and Deer Creeks. Table 1 indicates the drainage area of these sub-basins.

Table 1. Major Sub-basins of the Susquehanna River Drainage Area

Sub-basin	County, State		Area (Sq. miles)
Broad Creek	York, Pa.		0.6
	Harford, Md.		40.8
		TOTAL	41.4
Conowingo Creek	Lancaster, Pa.		33.6
	Cecil, Md.		5.0
		TOTAL	38.6
Octoraro Creek	Chester, Lancaster, Pa.		175.5
	Cecil, Md.		34.4
		TOTAL	209.9
Deer Creek	York, Pa.		25.2
	Baltimore, Harford, Md.		145.5
		TOTAL	170.7

HYDROLOGY

Precipitation and Temperature

The Susquehanna River basin is located in the generally humid eastern area of the United States. The average annual precipitation in the Maryland portion of the basin amounts to about 44.5 inches. The mean annual temperature is approximately 53.8° F.

Evapotranspiration

Much of the precipitation is returned to the atmosphere by evaporation (from water, plant and land surfaces) and transpiration, which is the loss of water exuded by plants. These processes combined, known as evapotranspiration, remove about 25.5 inches or 60 per cent of the annual precipitation in the nearby Little Gunpowder Falls watershed area, according to Dingman and Ferguson (1956). They estimated that evapotranspiration in the area varies from 33 per cent of monthly precipitation in February to 73 per cent in September. These estimates are probably good approximations of evapotranspiration for the Maryland portion of the Susquehanna River basin.

Streamflow - Surface and Ground Water Runoff

The U. S. Geological Survey gage at Marietta, Pennsylvania (30 miles above the Pennsylvania-Maryland boundary) is the most downstream station on the main stem currently providing streamflow measurements. Although a total of six gages have been operated for varying periods of record over the past 67 years in the Maryland portion of the basin, only the one on Deer Creek at Rocks, Maryland is still maintained. Data from the six gages were used by Darling (1962) in compiling a report on discharge characteristics of Maryland streams.

Table 2 lists the average and minimum daily flows of record for most of the stream gaging stations in the Susquehanna basin below Marietta, Pennsylvania. Also shown are probable low flows for two different design criteria: the 7-day, 10-year flow[1] and the daily flow which is exceeded 95 per cent of the time.[2] These design-flow criteria have been selected for presentation here only as examples of such criteria which have been used by regulatory agencies for purposes of stream water quality control.

Data from the 10 stations of record in the lower basin are summarized in Table 3. As indicated, the arithmetic mean of the average stream flow values is about 1.4 cubic feet per square mile. This is equivalent to approximately 19.0 inches of precipitation per year, or 42.5 per cent of the average annual total.

Table 3. Lower Susquehanna River Drainage Basin
Summary of Streamflow Data

Criterion of Flow	Number of Gaging Stations	Flow, cfsm Minimum	Median	Mean	Maximum
Minimum daily record	10	0.022	0.126	0.216	0.567
Probable low flow:					
7-day, 10-year	3	0.188	0.197	0.238	0.328
95- per cent duration	3	0.301	0.383	0.380	0.456
Average of Record	10	1.165	1.355	1.431	1.881

---

[1] That discharge average over a period of seven consecutive days which is exceeded by all such seven-day flows in nine out of every ten years (on the average).

[2] The lower five-percentile of the daily mean flows of record. This is the streamflow criterion used by the Maryland Department of Health as a basis for setting sewage treatment requirements.

Table 2. Average and Low Flows at Stream Gaging Stations - Susquehanna River Drainage Basin

Stream and Location of Gage	Period of Record	Drainage Area, Square Miles	STREAMFLOW							
			Average of Record		Low Flow					
					Minimum Daily of Record		Probable*			
							7-day, 10-year		Duration 95 Per Cent	
			cfs	cfsm	cfs	cfsm	cfs	cfsm	cfs	cfsm
Susquehanna River at Marietta, Pa.	1931-62	25,990	36,270	1.399	1,380	0.052	--	--	--	--
Conestoga Creek at Lancaster, Pa.	1928-62	324	387	1.194	7	0.022	--	--	--	--
Susquehanna River at McCall Ferry, Pa.	1902-11	26,800	39,830	1.486	1,200	0.045	--	--	--	--
Muddy Creek at Castle Fin, Pa.	1928-38	133	155	1.165	20	0.150	--	--	--	--
Broad Creek at Mill Green, Md.	1905-09	16.4	26.4	1.610	8	0.488	--	--	--	--
Octoraro Creek near Rising Sun, Md.	1932-58	193	253	1.311	22	0.114	38	0.197	74	0.383
Basin Run at Liberty Grove, Md.	1948-58**	5.3	6.7	1.269	0.5	0.094	1.0	0.188	1.6	0.301
Octoraro Creek at Rowlandsville, Md.	1897-99	210	395	1.881	102	0.486	--	--	--	--
Deer Creek at Rocks, Md.	1926-62	94.4	123	1.303	13	0.138	31	0.328	43	0.456
Deer Creek near Churchville, Md.	1905-09	141	239	1.695	80	0.567	--	--	--	--

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* Source: Darling (1962); probable low flows were adjusted by Darling to reference period 1913-1957.

** Adjusted for storage and diversion since October, 1951.

The value for streamflow or total runoff (in this case, 19.0 inches) represents the contribution of both surface and ground water runoff. Dingman and Ferguson (1956) found ground water runoff to account for 11.3 inches or 27 per cent of precipitation for the nearby drainage area of Little Gunpowder Falls above Laurel Brook, Maryland. An assumed value of 25% for the ground water contribution to streamflow in the lower Susquehanna basin is equivalent to about 11 inches of precipitation. This leaves approximately 8 inches of precipitation becoming streamflow via surface runoff.[3]

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[3] Expressed in terms of inches of precipitation:
Streamflow = Surface Runoff + Ground Water Runoff
19.0 = SRO + 25% x 44.5 (annual precipitation)
19.0 = SRO + 11.1
7.9 = SRO

INVENTORY OF SURFACE AND GROUND WATERS

The water resources of the Susquehanna River basin are found in its surface streams, lakes, and reservoirs, in the tidal portion of the main stem, and in the water-bearing formations underlying the watershed.

Surface Waters

Appendix A includes a list of streams comprising the surface drainage system of the lower Susquehanna River basin. The listing includes the main stem of the Susquehanna River in Pennsylvania and the larger tributaries flowing into the Susquehanna downstream of the most seaward gaging station on the main stem at Marietta, Pennsylvania. In addition to streams, Appendix A includes stream gaging stations, water intakes, waste outfalls, and other items of significance. A condensed list, including stream gaging stations, water intakes and wastewater outfalls is presented in Appendix B. A more detailed description of this material is found in the General Reference Section* under the heading, DESCRIPTION OF APPENDICES.

Reservoirs - Appendix C lists reservoirs and lakes in the Maryland portion of the Susquehanna watershed. There are no natural lakes in the drainage area. Of most significance in the lower basin is Conowingo Reservoir which was created by a dam on the main stem Susquehanna about five miles below the Pennsylvania line. Constructed for production of hydroelectric power, Conowingo Reservoir will soon serve also as a supplemental source of water supply for the City of Baltimore.

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* In this report, reference is frequently made to a General Reference Section. This section is found in the Summary Volume (Vol. 6).

Additional storage capacity is provided in the lower Susquehanna basin by smaller reservoirs and many farm ponds scattered throughout the rural areas.

Estuaries - The tidal waters of the lower part of the Susquehanna River are sometimes fresh, and other times salty, depending upon the flow of the river and other factors. During prolonged periods of low runoff, the salt-laden waters have advanced upstream in Chesapeake Bay and into the lower Susquehanna River. The saline waters, though unsuitable for potable supplies, have great value for use in industrial cooling and for instream uses such as recreation, navigation, fishing, and waste disposal. For these purposes, the users in the tidal zone of the river have a supply of water which is virtually unlimited, Chesapeake Bay.

Ground Water

The ground water of the lower Susquehanna River drainage area has been studied by the Maryland Department of Geology, Mines and Water resources (now called the Maryland Geological Survey) in cooperation with the U. S. Geological Survey. The accounts of these studies have been presented in detailed reports published by the State cooperating agency. The counties of the basin covered by these reports are listed in Table 4, together with the authors and dates of publication. The complete references for these reports are listed in the Bibliography at the end of this report.

The detailed reports mentioned above are the principal sources of available information on ground water in the basin. As they are published and readily available, it would be superfluous to repeat here much of the information contained in those reports. However, a brief summary of the information in the county reports pertaining to the Susquehanna drainage area is presented for convenience in considering the drainage area as a unit. Abstracts of the several county reports, originally published as parts of the reports, are reproduced in Appendix H. For detailed information, the original publications should be consulted.

Table 4. Published Reports on Ground Water, Susquehanna River Drainage Basin

County	Bulletin Numbers*	Principal Author	Year of Publication
Baltimore	17	Dingman	1956
Cecil	21	Overbeck	1958
Harford	17	Dingman	1956
Piedmont	-	Mc Guiness	1963
Coastal Plain	-	Mc Guiness	1963

* Numbers are those assigned in a series of reports issued by the Department of Geology, Mines and Water Resources, State of Maryland

The following is a very generalized description of the ground water of the Maryland part of the Susquehanna River basin.

In the Piedmont, good water commonly occurs under the uppermost 250 feet of the rocks and most wells and springs yield water derived from local recharge. The chief aquifers are the crystalline rocks which generally produce relatively low yields of water. For example, Dingman and Ferguson (1956) reported that more than 70 per cent of the drilled wells in the Piedmont portion of Baltimore and Harford Counties yield no more than 10 gallons per minute. Only 2 per cent have yields greater than 50 gallons per minute. The numerous wells scattered throughout the Piedmont area are used primarily for private household supplies, farm purposes and a few small canneries. There are three public water supplies in the Piedmont region of the Susquehanna basin - Rising Sun in Cecil County (0.046 mgd), Darlington (0.016 mgd) and Broad Creek Memorial Camp (amount used unknown) in Harford County. While additional ground water supplies are available for rural and domestic use, supplies for industrial and other large users are limited to an estimated maximum of a few hundred thousand gallons a day.

The Coastal Plain province occupies only a very small area of the Susquehanna River basin in Maryland; it consists of only a narrow strip of land below the Fall Line near the mouth of the river. Much of the ground water is found under artesian or semi-artesian conditions in confined aquifers of sand and gravel. Although comparatively large supplies of water are available, heavy pumpage is likely to induce saltwater intrusion because of the area's nearness to the tidal, brackish waters of the bay. There are no public water supplies and only a few industrial firms dependent upon ground water in this portion of the basin.

Compared to the tremendous quantities of surface water available in the lower Susquehanna River basin in Maryland, the area's ground water resources, while important on an individual or even a local basis, are of minor significance from a basin-wide viewpoint.

The natural runoff of the Susquehanna River basin has been regulated by man only to a relatively small degree. Although some regulation occurs as a result of interbasin diversions and reservoir operations, the effect is minor compared to the total runoff of the entire three-state drainage area.

Regulation by Reservoirs

At this time (1965), the principal means by which the natural water supplies of the Susquehanna River basin are modified is by reservoirs in each of the three basin states. For purposes of this report, no attempt has been made to identify all impoundments in New York and Pennsylvania. The more important reservoirs are described in recent "Water Supply Papers" of the Geological Survey (1962a). Four reservoirs in New York and three in Pennsylvania are listed in the most recent report of the series for the Susquehanna River basin (Water Supply Paper 1702, p. 427.) Others are known to exist but will not be considered in detail in this report.

Several of the reservoirs in New York and Pennsylvania serve the single purpose of flood control and have little significance to Maryland users of water for withdrawal purposes. At least three are operated for municipal water supply. These are Stillwater Reservoir on the Lackawanna River, a tributary of the Susquehanna in Susquehanna County, Pennsylvania; DeHart Reservoir on Clark Creek near Harrisburg, Pennsylvania; and Pine Grove Reservoir on Octoraro Creek in Chester County, Pennsylvania.

There are two impoundments on the lower Susquehanna River in Pennsylvania, and one in Maryland and Pennsylvania created for the purpose of hydroelectric power generation. In downstream sequence, these are

McCalls Ferry, Safe Harbor and Conowingo Reservoirs. The three dams forming these reservoirs are included in the hydrologic-sequence listing in Appendix A. These main-stem impoundments are used mainly to provide hydraulic head for power production; little of their storage capacity is used for seasonal flow regulation. The run-of-river flows are stored for relatively short periods and released to meet the daily and weekly peak power demands.

Conowingo Reservoir is formed by a dam across the Susquehanna River at a point 10.9 miles above the mouth of the river in Cecil and Harford Counties, Maryland. The distance from the dam upstream to the Pennsylvania-Maryland boundary is 5.4 miles as the river flows with the reservoir extending upstream well into Pennsylvania. The surface area of the impoundment is about 8,563 acres. The total storage capacity is approximately 308,000 acre-feet, but, according to Thomas and Harbeck (1956), the usable storage is 169,000 acre-feet with dead storage accounting for 139,000 acre-feet. Under normal operating conditions, the usable storage capacity is only 70,737 acre-feet. When this capacity is compared with the mean annual runoff of the Susquehanna River in excess of 26,000,000 acre-feet (as measured at Marietta, Pennsylvania), it becomes apparent that Conowingo Reservoir provides relatively little flow regulation of the river.

There are no major reservoirs on tributaries of the Susquehanna River in Maryland. A list of the 5 small impoundments in the Maryland portion of the basin is found in Appendix C with location and acreage data. A separate inventory and discussion of farm ponds is contained in the General Reference Section under the heading, "Water Resource Regulation and Distribution".

On some streams in the Eastern United States, it has been found economically feasible to provide storage capacity to hold as much as 75 per cent of the mean annual runoff. From this, it appears that only a very small part of the feasible storage capacity in the Susquehanna River basin has been developed.

Regulation by Diversion

In the broad sense, any withdrawal of water from a water body can be called a diversion. For purposes of this report, however, diversions include those withdrawals of water which are (1) discharged to another stream before or after use; (2) discharged to the same stream only at a point greatly distant from the withdrawal point so that the natural flows between the two points is affected; or (3) discharged to another watershed or drainage basin.

With respect to a given watershed, diversions may be classified as imports or exports.

Imports to Basin - At the present time (1965), there is only one known import diversion of water in the Maryland portion of the Susquehanna River Basin. The town of Perryville, located near the mouth of the Susquehanna in Cecil County, uses surface water from Mill Creek, a small stream which flows directly into Chesapeake Bay just east of the Susquehanna River. The water treatment plant serving Perryville has a capacity of 3.6 mgd and an average output of 0.18 mgd. After use, the water is discharged into the tidal reach of the Susquehanna River at a point 1.1 mile above its mouth,

No attempt has been made in this study to identify all imports of water into the basin in New York and Pennsylvania. However, those imports which are known are described below.

Hazleton, Pennsylvania, straddles the watershed divide between the Delaware and Susquehanna River basins. This city takes its water supply from both basins and also discharges its waste waters to both basins. However, it will soon have a new sewerage system which will discharge treated waste waters to the Susquehanna River basin only.

There will then be a net diversion of water by Hazleton into the Susquehanna River basin. Quantitative data on this diversion are not available at this writing.

The Delaware River Basin Commission granted approval in 1963 for a diversion of water from Bear Creek, a tributary of the Lehigh River in the Delaware River basin. This diversion, about 3 million gallons daily, will be for water supply in the Wilkes-Barre area of Pennsylvania. After use, the water will be discharged into the Susquehanna River, thus augmenting the natural runoff to the river upstream of Maryland.

Exports from Basin - According to the New York State Department of Health (1954), water is diverted from the Chenango River, a tributary of the Susquehanna River in New York, and is conveyed through the abandoned Chenango Canal to the Mohawk River and the New York State Barge Canal. This diversion takes place on the Chenango River about one-half mile upstream from Bradley Brook, due west of Hamilton, New York. The quantity of streamflow diverted is not known.

Two out-of-basin diversions are known to exist in the Pennsylvania portion of the Susquehanna River drainage area. Both are from Octoraro Creek, a tributary which flows into the Susquehanna River at river mile 10.2 or about 0.7 mile downstream of Conowingo Dam. The larger of the Octoraro Creek diversions is for the public water supply of Chester, Pennsylvania, in the Delaware River basin. The water is taken from Pine Grove Reservoir. During the calendar year 1963, the average monthly diversion rate varied from 23.1 million gallons daily in April to 27.3 million gallons daily in January, according to data reported by the Delaware River Basin Commission (1964).

The smaller diversion from Octoraro Creek is by the Octoraro Water Company in Chester County, Pennsylvania. Data reported by the Delaware River Basin Commission (1964) indicate that pumpage from Octoraro Creek during 1963 varied from an average rate of 0.55 million gallons daily in January to 0.92 million gallons daily in December.

It is noteworthy that the Susquehanna River has been mentioned as a potential future source of water for Philadelphia in the Delaware River basin (Phillips, 1961). However, many major reservoir projects for water supply and other purposes have been proposed and planned for development in the Delaware River basin upstream of Philadelphia. These projects will augment low flows in the Delaware and Schuylkill Rivers, the present sources of Philadelphia's water supply. These developments will lessen the probability that Philadelphia will need water from the Susquehanna in the foreseeable future.

At the present time (1964) a major project is under construction to divert water from the Susquehanna River for the public supply of the city of Baltimore and its suburbs. The intake for this new system is located in Conowingo Reservoir about 1,000 feet upstream of Conowingo Dam. The water will flow by gravity through a 108-inch pipe to a point near the mouth of Deer Creek. A pumping station will then force the water against gravity through another 108-inch pipeline some 27 miles across Harford County to the northeastern corner of the City of Baltimore, from where the water will flow by gravity through a 96-inch pipe to the Montebello Water Filtration Plant in Baltimore. This diversion project is designed for an ultimate capacity of 250 millions of gallons daily to the Baltimore system, more than the combined safe yields of the older Gunpowder and Patapsco River systems which now serve the Baltimore metropolitan area. The initial capacity of 150 mgd will be available about July, 1965. The ultimate capacity may be obtained by adding more pumps. An additional water treatment plant and a treated-water reservoir on the system are under consideration for the ultimate plan.

The Aberdeen Proving Ground diverts about 3.7 cfs (2.4 mgd) from Deer Creek, a tributary of the Susquehanna River in Harford County. After use, the waste water is discharged into Chesapeake Bay by way of Swan Creek and Spesutie Narrows. Although this diversion reduces the flow in Deer Creek, it does not add to streamflow in any fresh water stream of the Western Shore basin because the resulting effluents are discharged into the tidal waters of the Bay.

Net Diversion from Basin - The known diversions of water into and out of the Susquehanna River basin are listed in Table 5. The three presently operated diversion systems for which data are available export a total of 28.7 mgd (44.6 cfs) from the basin. With the completion of the Baltimore diversion system, the known potential exports from the Susquehanna basin will total up to a maximum of 279 mgd (430 cfs). This water, plus the unknown quantity diverted to the New York State Barge Canal, will more than offset the two small imports planned or under construction. Thus, the Susquehanna River basin will be a net exporter of water.

Table 5. Diversions of Water to and From Susquehanna River Drainage Basin, 1963

Source of Water	Water User	Water diverted to:	Mean Diversion, 1963			
			Exported		Imported	
			cfs	mgd	cfs	mgd
Susquehanna River North Branch Chenango River	New York State Barge Canal	Hudson River Mohawk River	Unknown	Unknown		
Delaware River Lehigh River Tributary	Hazleton, Pa.	Susquehanna River			(Planning State Only)	
Delaware River Lehigh River Bear Creek	Pa. Coal and Water Co.	Susquehanna River			4.7	3.0*
Chesapeake Bay, East Mill Creek	Perryville, Md.	Susquehanna River			0.28	0.18
Susquehanna River	City of Baltimore, Md.	Chesapeake Bay Back River Patapsco River	386.0	250.0*		
Susquehanna River Octoraro Creek	Octoraro Water Co. (Chester County, Pa.)	Delaware River	1.3	0.68		
Susquehanna River Octoraro Creek	Chester (Pa.) Municipal Authority	Delaware River	39.6	25.6		
Susquehanna River Deer Creek	Aberdeen Proving Grounds	Chesapeake Bay	3.7	2.4		

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*presently under construction

Canals and Aqueducts

No canals are found in the Maryland portion of the Susquehanna River basin, either for navigation or for conveyance of water. The lower few miles of the Susquehanna main stem are navigable by shallow-draft vessels. Major highways and railroads crossing the basin in the northeast-southwest direction provide transportation, obviating any need for navigation canals. To date, there has been no need for canals to move water in the area.

The existing aqueducts in the Susquehanna River basin have been discussed earlier in this report under the topic of diversions. They include the tunnel now under construction from the Susquehanna River to the City of Baltimore, and the two pipelines operated by the Octoraro Water Company and the Chester Municipal Authority, both of which divert water from Octoraro Creek in Chester County, Pennsylvania.

Undeveloped Reservoir Sites

There has been no comprehensive study of potential sites for reservoirs in the Maryland portion of the Susquehanna River basin. Those sites which have been investigated were reviewed in connection with various unrelated surveys aimed at single purpose objectives. The modern concept of multiple-purpose reservoir development has received little consideration in this area to date.

Reservoir Sites (1934 Study) - About 30 years ago, a group of "Advisory Engineers" (Gregory, Requardt, and Wolman, 1934) carried out a study of potential sources of additional water supply for the City of Baltimore. Their study included at least cursory examination of all larger streams, and some not so large, throughout the area from the Susquehanna River to the Potomac River and westward to the Monocacy River. Among the streams studied was Deer Creek, a tributary of the Susquehanna River.

The Advisory Engineers (Gregory et al, 1934) investigated seven dam sites on Deer Creek. After careful study of these sites, the engineers selected one designated "Rocks Dam Site No. 4" as the most favorable. This site is located at a point 24.1 miles above the mouth of Deer Creek, about 0.4 mile upstream of the bridge crossing of the Maryland and Pennsylvania Railroad. The drainage area above the site is approximately 92 square miles.

For this site, the engineers assumed a dam elevation of 425 feet above mean sea level and 146 feet above the stream bed. This elevation would result in an impoundment with a water surface of 3,650 acres and a gross capacity of 53 billions of gallons, of which 30 billions would be available by gravity. The gravity system supplemented by pumping would make available 45 billions of gallons. Assuming that 10 per cent of the usable storage should be held in reserve as a factor of safety, the Advisory Engineers computed the safe yield of the Deer Creek project to be 74 mgd, based on the 1930-1934 drought.

The estimated total cost of the dam and reservoir on Deer Creek, based on 1934 prices, was $7,572,000, including the cost of land and water rights; relocation of cemeteries, bridges, highways, railroad and power lines; fencing, dam construction; and contingencies and engineering. This estimate excluded the cost of a tunnel necessary to convey the water to a reservoir that would have been constructed earlier on Winters Run. This tunnel and additional water treatment facilities in the Baltimore water works would have increased the cost of the Deer Creek supply to $13,770,000, or $186,000 per mgd of added yield. This cost estimate was based on the assumption that the Deer Creek site would be developed as the third phase of a three-phase project, with two reservoirs constructed earlier - one on Little Gunpowder Falls and one on Winters Run. The first two phases included tunnels, from the Little Gunpowder reservoir to the Gunpowder Falls-Montebello tunnel and from Winters Run to the Little Gunpowder reservoir. Thus, the only conveyance system necessary for the Deer Creek phase was a tunnel from the proposed Deer Creek reservoir to the second-phase reservoir on Winters Run.

Status of 1934 Sites in 1964 - Since the 1934 study of the Deer Creek reservoir sites, Baltimore has constructed a large water supply impoundment on the Patapsco River and is now (1965) constructing a tunnel and pipeline from the Susquehanna main stem. These two projects, together with Prettyboy and Loch Raven Reservoirs on Gunpowder Falls, are expected to meet Baltimore's water requirements until after the year 2000. It is therefore unlikely that Baltimore will need to consider Deer Creek as an additional water source within the next 40 years.

The possibility exists, however, that some of the 1934 Deer Creek dam sites, if restudied from the viewpoint of multipurpose use to meet regional needs, might be found to be economical and worthwhile projects. For such a study, the data compiled in the 1934 investigation, as published in the report by Gregory, Requardt, and Wolman (1934), as well as the unpublished material supporting that report, would be invaluable. The unpublished materials are to be found in the custody of the Bureau of Water Supply of the City of Baltimore. A list of these materials is given in the Appendix of the 1934 report.

Underground Storage Possibilities

Piedmont Province - There has been no comprehensive study of underground storage possibilities in the Susquehanna River drainage area in Maryland. A review of the available information on the Piedmont province leads to the conclusion that there is little possibility in that portion of the Susquehanna basin for development of extensive groundwater storage. Such storage as exists is in the weathered mantle overlying the firm rock. The fractures in which water can be stored extend downward only a few hundred feet at most below the surface. Whatever natural storage capacity that exists, if used to regulate the seasonal water-supply variations by heavy pumping during dry seasons, would probably refill with recharge during wet seasons. There is no evidence that water is being "mined" without being replenished in this part of the country as has happened in the less humid western region of the United States.

Coastal Plain Province - The small area of the Coastal Plain province, the relatively shallow depth of the unconsolidated sediments in the area, and the nearness of the brackish waters of Chesapeake Bay and the tidal reach of the Susquehanna River probably precludes the possibility of any major underground storage developments for water conservation in this province within the Susquehanna River basin.

Individual households and other users of small quantities of water can generally utilize the available storage capacity of the Coastal Plain aquifers. It is necessary only to pump them down as water is needed. The drawdown will induce recharge to replenish the water removed.

There is no use of artificial recharge of aquifers in the Susquehanna River basin in Maryland, other than subsurface disposal of waste waters from septic tanks serving single-family dwellings. Because of the relative abundance of surface water resources in this area, it is unlikely that any planned recharge systems will be needed in the foreseeable future.

INVENTORY OF SURFACE WATER USES

Surface water uses can be classified as withdrawal or instream uses; the latter classification can be further subdivided into flow and on-site uses. These terms and others are described in the General Reference Section under the heading, Surface Water Uses. Tabular material concerning water use appears in the following appendices:

Appendix B - intakes, outfalls, gaging station records
Appendix E - surface water permits
Appendix F - ground water permits

The amount of water consumed (i.e. actually removed from available supply - see the discussion in the General Reference Section) is only a small part of the total used. Most of the fresh water taken from streams in the lower Susquehanna basin is used for public water supplies. Various authorities have estimated that from 5 to 20 per cent of water entering municipal distribution systems is consumed. The remainder, after use, is normally available for reuse after treatment to remove impurities or after purification by natural processes in surface streams or aquifers into which the used but unconsumed water is discharged.

In areas such as the lower Susquehanna basin, however, where much of the population and industry using fresh water are located near brackish or saline water bodies, the practice of discharging once-used fresh water into these salty waters prevents reuse. Once mixed with the salt-laden waters, the waste waters are no longer available for reuse as fresh water.

Since the waste waters discharged into brackish or saline waters are effectively removed from the available supply of fresh water as effectively as if they were evaporated or transpired, such discharge is similar in effect to a consumptive use. This is especially noteworthy in the lower

Susquehanna basin of Maryland near Chesapeake Bay. While it has become popular to argue that generally waste waters can be reused in preference to more expensive development of new supplies, this probably is not the case in the lower Susquehanna basin.

Withdrawal Uses

The withdrawal uses of surface waters can be classified as municipal, institutional, industrial or agricultural uses. A fifth category sometimes employed is rural-domestic use but this seldom involves surface water. Only the first four classifications need be discussed for the lower Susquehanna basin.

Municipal and Institutional Surface Supplies - Table 6 lists the Maryland communities and institutions which take water from surface streams of the Susquehanna River drainage area. Even considering Baltimore's expected withdrawal of 150-250 mgd beginning in 1965, the total quantity withdrawn is insignificant compared to the dependable supply of fresh water available in the Maryland stretch of the lower Susquehanna and its tributaries.

By legislative act, Baltimore City is obligated to sell Harford County up to 10 million gallons of raw water daily from its conduit to the Susquehanna when it becomes operative. The legislation also stipulates that 4 taps will be installed along the conduit by Baltimore to serve Harford County.

A report prepared for Cecil County (Marcou, O'Leary & Associates, 1965) indicates the Susquehanna to be a feasible source of supply for meeting future water needs. The Northeast River was considered to be a logical alternative. According to the report, population growth will occur most rapidly along the Route 40 - Northeast Expressway Corridor of election districts 3, 5 and 7. These districts had a 1960 population of 33,000 (about two-thirds of the total County population) and include the communities of Port Deposit, Perryville, Northeast and Elkton. Data in the report infer that present supplies in the three districts with a capacity of 3.0 mgd will be inadequate before 1980; water requirements are expected to exceed 5.0 mgd by 1980 and to reach 7.0 mgd by the year 2000. To meet future requirements, a 14 mgd filtration plant and 7 million gallons of potable storage will be required. Cost of the entire project including supply, treatment, transmission and storage was estimated at 8.8 million dollars.

Industrial Surface-Water Supplies - There are no major industrial users of surface water in the Maryland portion of the Susquehanna basin.

Table 6. Municipal and Institutional Surface Water Supplies, Susquehanna River Basin, Maryland

Name of Community or Institution	Location of Intake, Sub-basin and Source Stream	Mean Withdrawal	
		Year	mgd
Aberdeen Proving Grounds	Deer Creek	1962	2.42
Bainbridge Naval Training Center	Main Stem Susquehanna	1964	1.2
Baltimore City	Main Stem Susquehanna	*	250.0
Broad Creek Memorial Scout Camp	Broad Creek Deep Creek		unknown
Conowingo	Main Stem Susquehanna	1964	0.011
Girl Scout Camp	Conowingo Creek	--	unknown
Havre de Grace	Main Stem Susquehanna	1964	1.0
Veterans Administration Hospital, Perry Point	Main Stem Susquehanna	1962	0.5

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*withdrawal by Baltimore to begin in 1965

Agricultural Use of Surface Waters - The use of water for agricultural purposes has never been extensive in the Susquehanna River basin in Maryland. Farmers in this part of Maryland, as in the rest of the State and throughout the humid Eastern states, have depended until quite recently upon natural rainfall during the growing season plus water stored in the soil to supply the moisture needed by growing crops. Since World War II, however, there has been a trend of increasing use of water for supplemental irrigation in the East. For example, Reynolds (1955) reported that in the entire State of Maryland, the number of acres irrigated increased from 700 in 1949 to 12,000 in 1954 and 20,000 in 1955. He did not specify the amounts of surface water included in these figures. Earlier, MacKiohan (1951) had reported that 1,000 acre-feet of ground water and a "negligible" quantity of surface water were used for irrigation in Maryland in 1950. However, in 1957, according to Meyer (1957), Maryland irrigators used 206 acre-feet per day (67.2 mgd) to supplement rainfall on 12,233 acres with only six per cent of the water coming from wells; the rest was taken from streams, estuaries, and ponds.

While no specific data concerning irrigation in the Susquehanna basin is available, Meyer (1957) has compiled information for the entire Piedmont physiographic province of the State. This seven-county area includes most of the Susquehanna basin in Maryland. A summary of Meyer's findings is found in Table 7.

Other sources of data on the use of irrigation water in Maryland are MacKichan (1957), Galbreath (1960), Boyer (1958), Bureau of the Census (1956), Carbaugh, et al (1960), Bohanan (1956), Krewatch (1957), and Beauchamp (1958).

A discussion of consumptive use in irrigation is found in the General Reference Section under the heading, Inventory of Surface Water Uses, Withdrawal Uses - Irrigation. Also discussed is the effect of irrigation on streamflow records and certain administrative aspects of irrigation.

Since there are considerable lands in the Susquehanna basin near the tidal waters of the lower Susquehanna River and Chesapeake Bay, it is worth mentioning here that these tidal waterways have fresh or only slightly saline waters in their upstream reaches at times. By selectively withdrawing water at such times (for example, a low-water slack tide), farms near these upstream reaches may be able to obtain water adequate in quantity and satisfactory in quality to meet their irrigation needs. (Law and Renfro, 1955). Water from these tidal streams will not as likely become the subject of conflicts or litigation as water from streams farther inland.

Table 7. Water Use for Supplemental Irrigation in
Piedmont Province of Maryland, 1957*

Physiographic province:	Piedmont**
Average use in irrigation season:	
mgd:	20.6
acre-feet per day:	63.0
Area irrigated, acres:	3,466.0
Average amout applied per acre:	
gallons per day:	5,900.0
acre-feet per day:	0.018
Increase in acreage irrigated	
1949-1957, per cent:	5,400.0
1954-1957, per cent:	17.0
Source of Water, per cent:	100.0
Streams or estuaries, per cent:	64.0
Ponds, per cent:	34.0
Wells, per cent:	2.0

Method of distribution, per cent:	100.0
Sprinkler, per cent:	90.0
Ditch, per cent:	10.0

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* Source: Meyer (1957)

** The Piedmont province includes all or nearly all of Cecil, Harford, Baltimore, Carroll, Frederick, Howard and Montgomery Counties, about one-fourth of the land area of the State.

Instream Water Uses

Water uses which do not require removal of water from its natural surface waterway are frequently termed *non-withdrawal* or *instream* uses. These uses include hydroelectric power generation, navigation, fishing, recreation and waste disposal. Although these instream functions are non-consumptive, the use of water for any one of them may - and frequently does - conflict with uses for other non-withdrawal uses. On the other hand, provision of water in a stream for one purpose may automatically provide more water for other purposes. For these reasons, instream water uses must be considered in any evaluation of water supply and demand.

Hydroelectric Power Generation - The use of hydraulic head for the generation of power is a very important instream use in the Susquehanna drainage area. Hydromechanical power was known through the Piedmont area, and especially on streams near the Fall Line, where the available hydraulic head was converted to mechanical energy primarily for the milling of grain. As late as 1929, Mathews and Watson (1929) reported that the Piedmont streams of Baltimore County "...develop considerable water power which is used locally for small milling and manufacturing purposes."

The Philadelphia Electric Power Company and the Susquehanna Power Company, both subsidiaries of the Philadelphia Electric Company, operate a large hydroelectric power generating station on the Susquehanna River at Conowingo, Maryland. According to the Federal Power Commission (1962), the Conowingo hydro plant has a capacity of 252 megawatts. The turbines use an average of 20,000 cfs, or 13,000 mgd. This plant, operated under a 50-year Federal Power Commission license which expires in 1976, is being modified by the addition of four new generating units. These units will increase the installed capacity to 493 megawatts and the net book cost of the plant to $58,500,000. The operating companies have applied to the Federal Power Commission for a new 50-year license covering both the Conowingo plant and a pumped-storage hydroelectric project on Muddy Run, a tributary of the Susquehanna River (Federal Power Commission, 1963). The Muddy Run project site is in Lancaster County, Pennsylvania.

Except for the main stem, the streams in the Maryland portion of the Susquehanna River basin have little or no potential for economically feasible production of conventional hydroelectric power. The smaller streams could not support such developments because of insufficient flow, inadequate range of elevation, or both.

Recently, great interest has developed in this country in the production of hydroelectric power by the so-called pumped-storage method. This method uses off-peak power from another source, such as a steam-electric station, to pump water from a low-elevation source to a high-elevation reservoir. During periods of peak demand for energy, the high-level water is passed through the combination pump-turbines to supplement the base power capacity of the system. Since pumped-storage facilities use more energy when pumping than they produce when generating, they are economically feasible only if the overall value of the energy generated is greater than the cost of pumping. This is possible because of the difference between the prices of energy in periods of peak and low demand.

It should be noted that pumped-storage schemes usually rely upon recirculation of water, and therefore have little effect upon the average water supply available for other purposes. However, they may cause daily or weekly fluctuations of streamflow, depending upon the physical scheme employed.

Although there are no pumped-storage projects in existence in the Maryland portion of the Susquehanna basin as of 1964, there is probably a potential for development of such facilities, as evidenced by the recent proposal for a project of this type on Muddy Run, a tributary of the Susquehanna River which discharges into Conowingo Reservoir at a point 23.8 miles above the mouth of the Susquehanna. The site of the dam that would form the upper reservoir is on Muddy Run about one-half mile above the mouth. Conowingo Reservoir would serve as the lower reservoir of the pumped-storage system. The Muddy Run-Conowingo project would have a capacity of 800,000 kilowatts. The estimated cost of the project is $79,000,000. It would be built by the Susquehanna Power Company and the Philadelphia Electric Power Company, both subsidiaries of the Philadelphia Electric Company. The subsidiaries have applied to the Federal Power Commission for a 50-year license which would include authorization to continue to own and operate the existing Conowingo project on the main stem of the Susquehanna River in Maryland. The license for the Conowingo Project will expire on February 19, 1976 (Federal Power Commission, 1963).

Navigation - Navigation is not a very important feature of the instream water uses in the lower Susquehanna River basin. Although the main stem of the Susquehanna is directly connected with Chesapeake Bay, it is too shallow for large vessels. However, it is used extensively by smaller craft, including pleasure boats. Sport fishermen also ply the waters of the river up to Conowingo Dam in shallow-draft boats. Above the dam, Conowingo Reservoir is used by small craft. There is no lockage system to allow vessels to pass the dam.

According to the Corps of Engineers (1963), Congress has authorized a Federal navigation project which the Corps describes as follows:

> The existing project provides for a channel 200 feet wide and 15 feet deep from that depth in Chesapeake Bay to Havre de Grace, for removal of the shoal opposite Watson's Island (also called Garrett Island) to a depth of 8 feet; the improvement and maintenance of the existing small boat harbor below Concord Point at the mouth of the river for a width of 380 feet and a length of 400 feet, with an approach channel 100 feet wide, all to a depth of 10 feet.

The project is essentially completed except for the small boat harbor and channel. According to the Corps of Engineers (1963), this phase of the project is inactive. As of 30 June 1963, the Federal Government has spent $270,665, exclusive of funds of $22,905, for new work on the project and $116,968 for maintenance.

Several marinas and other facilities for berthing and servicing yachts and fishing craft are located along the shores of the lower main stem of the Susquehanna. These establishments do a thriving business and are important features to the economy of the area.

Information of interest to navigators and yachtsmen is presented in the "United States Coast Pilot," issued by the Coast and Geodetic Survey (1916), and on the latest revision of navigation chart 1226, also issued by the Coast and Geodetic Survey. The Corps of Engineers (1937, 1939) has prepared two reports which include information on navigation in the Susquehanna River. Both of these reports were published as congressional documents.

Fishing - Although the fishery resources depend upon high quantities of water in the streams and estuaries, the use of water by fish and fishermen is nonconsumptive. Like navigation, fishing is important in a water resources survey mainly because of its water-quality aspects. Unlike navigation, however, fishing is of concern primarily because of its needs for water of reasonably good quality, rather than for its effects on water quality.

From Conowingo Dam to the mouth, the main stem of the Susquehanna River supports a sports fishery of great economic value. Resident and anadromous species of fish attract large numbers of fishermen. The spring spawning runs of the shad provide recreation and food for thousands of sportsmen. At present the upstream limit of this annual migration is Conowingo Dam. However, a recent investigation led to a recommendation that fish-passage facilities be provided at the dam to restore the shad fishery upstream of this obstacle (Bell and Holmes, 1962).

The Susquehanna River above Conowingo Dam and its tributaries support a fresh-water fishery of importance. The division between the fresh-water and salt-water fisheries is not always distinct, but regulations issued by the Department of Game and Inland Fish mark the legal point of division on each stream extending inland from the tidewater area on which fresh-water fishing is controlled by licensing. No license is required for tidewater fishing in Maryland. The points of division, where known, are listed in their hydrologic sequence in Appendix A.

Although the quality of stream waters is of primary concern to fishing interests, the quantity of water available in fish habitats is also an important aspect of water resources management. Streams can be ruined for fishing by extended droughts which dry up long reaches (Schaut, 1939), or by excessive diversions. Rapid fluctuations of streamflow and river level resulting from peaking-power operations can be annoying or even dangerous to fishermen.

The adverse effects of these fluctuations on the fish habitat downstream of Conowingo Dam was clearly illustrated in the past year (1965). During the spring, several significant fish kills were recorded in the area immediately below Conowingo Dam. State resource agencies blamed these kills on the lack of an adequate flow of water being released from behind the dam. In one instance, the low-flow conditions occurred when a large concentration of herring existed in the dam tailrace at the peak of their spawning run. Sixty eight tons of fish, mostly herring, were killed. Fishing scientists pointed out that fortunately the white shad run had not occurred at the time, and thus a major commercial fishing loss was prevented. The utility company and the resource agencies are now preparing a plan involving maintenance of sufficient streamflow and possibly some downstream improvements (creation of pools by jetties and groins to reduce the effect of streamflow fluctuations) to avert future occurrences of these fish kills.

Much of the available information on the fishery resources of the Maryland portion of the Susquehanna River basin can be traced through reference to a bibliography prepared by Mansueti (1955).

Recreation - In addition to sport fishing, recreational boating is an important use of the main stem of the Susquehanna River in Maryland, especially in the tidal reach near the mouth. Conowingo Reservoir is also popular as a boating and water skiing area.

Except for Conowingo Reservoir, the non-tidal waters of the lower Susquehanna basin are not used extensively for boating. Most of the streams are too small and shallow for boats. The recreational use of these streams is largely restricted to fishing.

Two state parks are located in the basin area and both are situated so as to take advantage of nearby flowing water. Rocks State Park is located 8 miles northwest of Bel Air (Harford County) on Deer Creek. A portion of the stream running through the 272 acre park is stocked with trout. Still under development is the 1200 acre Susquehanna State Park located about 2 miles below Conowingo Dam on the Harford County side of the river. In addition to its other facilities, the park is particularly inviting to fishermen especially during the spring migration of the shad upstream as far as the dam and into Octoraro and Deep Creeks.

Waste Disposal - A general discussion of waste disposal may be found in the General Reference Section under the heading, Inventory of Instream Surface Water Uses.

Appendix B lists waste outfalls in the Maryland portion of the Susquehanna basin, and if known, quantities of waste discharged. There are 4 municipal and 3 institutional outfalls in the Maryland portion of the basin with a total waste-water discharge of about 1.9 mgd. The discharge from Havre de Grace (with a sewered population of 9,000) is the largest in the Maryland portion of the basin - 800,000 gpd. Information on municipal and institutional waste discharge in the entire Susquehanna basin is summarized under the water quality section of this report. Detailed data are contained in a recent report by the Public Health Service (1964).

As indicated in Appendix B, less than 200,000 gpd of waste water are known to be discharged by industries in the Maryland portion of the basin. This amount represents the discharge of only 6 of the 11 industrial outfalls in the basin. Additional information will be provided by an industrial water survey by the basin states in cooperation with the Chesapeake Bay-Susquehanna basin project of the Public Health Service.

GROUND WATER USE

Ground water is used throughout the Maryland portion of the Susquehanna basin by farms, individual households, scattered industries and two small communities. Rising Sun, located in Cecil County within the watershed of Octoraro Creek, had a population of 824 in 1960. Its water system, supplied by three wells, serves a population of 855 according to a recent report of the Public Health Service (1964). The average output of the water works is about 0.046 mgd. Broad Creek Memorial Camp, used by the Boy Scouts, withdraws a small but unknown amount of ground water.

Darlington, a small community in Harford County with a 1960 population of 250, serves well water to a connected population of 160. The average pumpage of the wells was reported by the Public Health Service (1964) to be 0.016 mgd.

There are no community ground water supplies in the small areas of Baltimore and Carroll Counties which are in the Susquehanna River basin.

Overbeck and Slaughter (1958) estimated that about 750,000 gallons of ground water were being pumped from wells in the entire Piedmont area of Cecil County. They reported that nearly all of this water was used for farm and domestic purposes. In addition to Rising Sun, they listed Perryville as using ground water, although the more recent report by the Public Health Service (1963) lists Perryville as now using surface water from Mill Creek. Inasmuch as less than a third of Cecil County is within the Susquehanna River basin, the total ground water pumpage from the aquifers underlying Cecil County in the Susquehanna drainage area is probably less than 500,000 gallons (0.5 mgd).

Dingman and Ferguson (1956) reported that the amount of ground water pumped from the crystalline-rock area of Baltimore and Harford Counties is estimated to be about 4,000,000 gallons a day, most of which is from wells used for domestic or agricultural purposes. Only a small amount of ground water is used for light industrial or commercial purposes. During the canning season, a few canneries in the (two) counties use an estimated 200,000 gallons per day of ground water for processing.

Since only a very small part of Baltimore County and only about half of Harford County are in the Susquehanna River basin, the total ground water used in the Susquehanna drainage area within these two counties must have been considerably less than the 4 mgd reported by Dingman and Ferguson (1956). Based on approximate proportions of the county areas in the basin, it is estimated that ground water pumpage in the Susquehanna watershed in Baltimore and Harford Counties amounted to less than one mgd as of the 1956 report.

More recent published estimates of ground water use are not available. For those election districts which lie partly or entirely within the basin, population increases between 1950 and 1960 allow only modest increases in the estimates of ground water use presented by Dingman and Ferguson (1956) and Overbeck and Slaughter (1958). As a tentative figure for 1964 use of ground water in the Maryland portion of the Susquehanna basin, 2 mgd is suggested. This amount is small compared to the quantity of surface water withdrawn from streams in the same area, even before the completion of Baltimore's Susquehanna diversion project.

Appendix F contains a list of water users holding permits from the Department of Water Resources to take and use ground water. The law requiring such permits exempts several types of water users. Moreover, the law does not require permit-holding water users to report the amount of water actually used. Therefore, the list in Appendix F does not give any indication of the total amount of ground water withdrawn. Data are needed to show actual withdrawals by permit holders as well as by those not required to have permits.

WATER QUALITY

As Maryland's greatest source of fresh water, the Susquehanna River is an economic asset not only to the three-county area within its own drainage area, but also to the entire Western Shore area of Maryland between the Susquehanna and Potomac Rivers. Ultimately, the Eastern Shore of Maryland may also obtain water from the Susquehanna. Because of the size of the drainage area, the quantity of water flowing into the Maryland portion of the basin from New York and Pennsylvania will more than meet the withdrawal needs in the Susquehanna River water-service area of Maryland, barring major diversions or flow-regulation projects upstream. However, the quality of water in the Susquehanna River and its tributaries is also important and must be considered in the evaluation of the basin's water resources.

Water-Quality Criteria

A general discussion of water-quality criteria may be found in the General Reference Section under similar heading.

Water-Quality Problems - Natural

Probably the most significant water-quality problem that can be attributed to nature in the lower Susquehanna River is sea-water intrusion. During extended periods of subnormal runoff from the drainage area of the river, the brackish water of Chesapeake Bay is brought into the lower reach of the Susquehanna by tidal mixing forces. For example, in a 1930 study reported by Schaefer (1931), the State Department of Health found chloride concentrations as high as 770 parts per million at a location upstream of the public water supply intake of the city of Havre de Grace. Schaefer reported that the public supply became so saline that previously abandoned wells and springs were put into service.

During the same drought of 1930, the town of Port Deposit, located a few miles upstream of Havre de Grace, also observed salinity intrusion. Port Deposit's normal source of water was Fast Rock Run. When the flow in this stream became inadequate, water was pumped from the Susquehanna River by a fire engine. After two weeks, the use of Susquehanna River was stopped because of its high salt concentrations, according to Schaefer (1931). Since the 1930 drought, the State Health Department has not received any complaints concerning salinity intrusion into municipal supplies.

The occasional presence of saline water in the lower Susquehanna River places a restraint upon the withdrawal of ground water from the aquifers near the river because of the danger of sea-water intrusion into these aquifers. Such intrusion would accompany heavy pumping and lowering of fresh-water levels in those aquifers hydraulically connected with the tidal river.

Another problem related to salinity, discussed elsewhere in this report, is the permanent loss from fresh-water resources of sewage and industrial wasted discharged into the brackish tidal waters. The used water discharged into the lower Susquehanna during periods of drought, such as that of 1930, are thus lost when they are most likely to be needed.

The concentrations of fluoride in the surface waters of the Susquehanna River drainage area are lower than believed desirable in potable water for the prevention of dental caries (Public Health Service, 1962). Limited data are available showing fluoride concentrations of 0.2 parts per million or less in various Susquehanna River tributaries in Pennsylvania (Durfor and Anderson, 1963) and in Deer Creek in Maryland (Dingman and Ferguson, 1956). These values are well below the usual objective of 1.0 ppm in potable supplies. The Baltimore water works, which will soon be diverting water from the Susquehanna, will add fluorides to this water as it now does to the water taken from Gunpowder Falls and the Patapsco River.

Natural quality problems related to ground water in the Susquehanna River Basin are generally not very serious. According to Dingman and Ferguson (1956), the chemical quality properties most important to ground-water users in the Piedmont area of Baltimore and Harford Counties are dissolved solids, hardness, iron, pH and carbon dioxide. They reported that dissolved solids in 51 samples of ground water averaged 105 parts per million, which is only moderately hard. The hardness in 60 samples averaged 59 parts per million, which may be classified as soft. They reported generally low iron concentrations, even though some samples showed iron as high as 3.5 parts per million. Iron is present in some ground waters in concentrations (greater than 0.3 ppm) causing unpleasant taste as well as staining of bathroom fixtures, cooking utensils and laundry. Water in most of the acid crystalline rocks commonly has a pH below 7. Such water, unless neutralized, tends to corrode pipes, well casings, pumps and other equipment with which it comes in contact. Dingman and Ferguson reported concentrations of carbon dioxide ranging from 2.2 to 47 parts per million. The higher concentrations of this dissolved impurity indicate a water that is likely to be corrosive.

Fluorides are generally low in the ground waters of the Piedmont area. Dingman and Ferguson (1956) found fluoride concentrations less than 0.2 parts per million in all well samples analyzed.

Water Quality Problems - Man-made

A general discussion of water-quality problems caused by man's activities is found in the General Reference Section. In the following narrative, specific water-quality problems resulting from unnatural causes are discussed for various sub-basin areas of the lower Susquehanna River basin. Although the assigned geographic scope of this study was limited to the State of Maryland, it is well to consider briefly the general out-of-State factors controlling water quality within Maryland in the lower Susquehanna River basin. Table 8 summarizes a recent Public Health Service (1964) report on community waste data in the upper basin. (A similar report on industrial waste discharges will be available sometime during 1965.)

Susquehanna River Basin in New York - Prior to the present comprehensive studies being conducted by both Federal and State agencies, the New York portion of the basin , some 6,200 square miles, was extensively studied by the New York State Department of Health (1954). In its report the Department listed all known sources of waste discharge, including municipalities and industries. The lower reach of the North Branch of the Susquehanna River from Binghamton to the New York-Pennsylvania boundary was characterized as polluted. However, it was noted that the stream quality recovers generally from below Endicott to the State line near Waverly, New York, where the North Branch leaves New York for the last time. Analytical data for this point showed reasonably good water on 8 July 1953. Nothing in the 1954 New York report gives cause for concern on the part of water users downstream in Maryland.

Susquehanna River in Pennsylvania - Only the reach of the main stem from Harrisburg to the Pennsylvania-Maryland boundary will be considered here.

Table 8. Community Waste Facilities Susquehanna River Basin-Pennsylvania and New York

Sub-basin	Total Number of Facilities	Total Population Served	No Treatment		Primary Treatment		Secondary Treatment		Facilities Needing Improvement[1]	Plants being designe or unde construc tion
			Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served		
North Branch, N.Y.	65	330,215	21	74,780	31	179,330	13	76,105	26	2
North Branch, Pa.	110	584,220	65	475,629	15	70,661	30	37,930	66	4
West Branch, Pa.	71	197,757	32	32,576	18	124,076	21	41,105	17	5
Juniata River, Pa.	52	167,933	14	21,149	6	26,210	32	120,574	15	5
Lower Main Stem, Susquehanna, Pa.	158	724,396	34	112,309	23	196,968	101	404,319	30	15
TOTAL	456	2,004,521	166	716,443	93	597,245	197	680,033	154	31

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[1] as determined by the respective State agencies

Source:

In a recent report, Durfor and Anderson (1963) discussed the chemical quality of surface waters in Pennsylvania, including those of the Susquehanna River basin. They reported evidence of acid mine drainage at Harrisburg which they attributed to the anthracite coal fields to the east of the main stem. The acid wastes reach the Susquehanna via tributaries draining westward from the coal fields. The pH of the river water is lowered along the east bank of the main stem as far downstream as Columbia, Pennsylvania, which is about 25 miles below Harrisburg and 44 miles above the mouth of the Susquehanna River (about 28 miles upstream of the Pennsylvania-Maryland boundary).

Maryland water users have a great interest in the nuclear power station recently constructed near Peach Bottom, Pennsylvania, on the Susquehanna River at a point 19.9 miles above its mouth, only 3.6 miles upstream of the Pennsylvania-Maryland boundary. Because of the importance of the Susquehanna River as a source of potable water for Baltimore and other Maryland cities, the Bureau of Environmental Hygiene of the Maryland State Department of Health is maintaining surveillance of water quality in the area near the Peach Bottom plant. In a survey planned in 1960 (Johnson and Brown, 1960), the Bureau sought to establish pre-operation data on environmental factors that might be affected by radioactive contaminants in the reactor effluents. After the plant has been in operation for a while, the sampling program will reveal any significant changes.

Numerous municipalities and industries discharge wastes into the Susquehanna River and its tributaries in Pennsylvania. Most of these waste sources are relatively distant from the Maryland portion of the basin and have had little effect on water uses in the downstream State up to the present time (1965). Data for these discharge points are listed in the references cited previously.

Susquehanna River Basin in Maryland - Known land-based sources of waste discharge in the Maryland portion of the Susquehanna River basin are listed in Appendix A. Largely rural, the basin area has no large cities and only a few incorporated places. The basin areas within Baltimore and Carroll Counties contain no incorporated communities. Cecil County has three incorporated towns in the basin: Rising Sun in Election District 6, and Port Deposit and Perryville in Election District 7. Election District 8 (entirely within the Susquehanna Basin) and Election District 9 (partially within the basin) contain no incorporated cities or towns. The portion of Harford County which drains into the Susquehanna River includes part of Election District 6, the boundaries of which coincide with the town of Havre de Grace. Other subdivisions of Harford County which drain partly or wholly into the Susquehanna River are Election Districts 2, 3, 4 and 5, none of which has any incorporated places in the basin.

Until recently, Rising Sun discharged 37,000 gpd of sewage from 750 persons into a tributary of Octoraro Creek (Stone Run) from an obsolete primary treatment plant. The dilution of these wastes was at times because of upstream diversions from Octoraro Creek above the Pennsylvania-Maryland State line. The relatively small discharge had a negligible effect on water quality in the Susquehanna main stem; moreover, Rising Sun has recently placed into operation a waste stabilization lagoon.

Port Deposit is located on the east bank of the Susquehanna River about five miles above the mouth. In 1960, the population of this town was 953, less than in 1950 (1,139) and even less than in 1920 (1,090). Sewage from the entire population is discharged untreated to the river.

Perryville with a 1960 sewered population of 550 discharges untreated sewage into the Susquehanna River at a point on the east bank about a mile above the mouth. This situation will be remedied, however, by the construction of a sewage treatment plant on the grounds of the Perry Point Veterans Administration Hospital. Under a cooperative arrangement, the treatment plant will provide secondary treatment for sewage from both Perryville and the Federal hospital.

Havre de Grace is situated at the mouth of the Susquehanna River on the western bank. The 1960 population of this town was 8,510, about 700 persons more than in 1950. Some 9,000 persons are served by the public sewers which discharge waste waters without treatment into the Susquehanna River at a point about 0.8 miles above the mouth. The town is now under orders from the State Department of Health to provide a sewage treatment plant.

The only unincorporated sewered community in the Maryland portion of the Susquehanna drainage area is Conowingo in Harford County. The sewerage system serves a population of about 90. After primary treatment, the effluent is discharged into the main stem of the Susquehanna River at river mile 10.9 below Conowingo Dam.

Two institutions of the Federal government are located in the Susquehanna River basin in Maryland, both in Cecil County. The Bainbridge Naval Training Center, near Port Deposit, discharges effluent from a secondary treatment plant into Happy Valley Branch, a small tributary which flows into the Susquehanna River 4.8 miles above its mouth. The rate of discharge is reported to be 0.6 mgd. The other government establishment is the Veterans Administration Hospital at Perry Point at the mouth of the Susquehanna. This installation now discharges about 0.35 mgd of untreated sewage, but will be served by the sewage treatment plant being constructed with the town of Perryville.

It is estimated that the 1965 unsewered population within the Maryland portion of the basin is about 35,000. These residents of the basin largely depend on individual household sewage disposal systems such as septic tanks and cesspools.

Scattered industrial waste discharges are found in the Maryland area of the Susquehanna basin. Most of these are small, causing only local degradation of water quality. They are listed in Appendices A and B.

Interstate Problems

As the downstream recipient of Susquehanna water, Maryland must be concerned with upstream contamination, flow regulation, diversion or other factors that would degrade the quality of water available to it. The influence of existing upstream development and water use does not create any obvious limitations or the use of Susquehanna water in Maryland. Although quality problems are known to exist in the New York and Pennsylvania portions of the basin, these are solved generally by a combination of pollution-abatement measures, dilution and natural stabilization of wastes in the river and its impoundments before the water reaches Maryland.

Cumberland (1961) has called attention to the atomic power electric generating station at Peach Bottom, Pennsylvania, on the Susquehanna River, as a potential source of radioactive contamination in Chesapeake Bay. However, extensive precautionary measures have been carried out in connection with this project to minimize the danger to water users. Such users will include the City of Baltimore, which is soon to begin diverting water from the Susquehanna downstream of Peach Bottom.

Pollution of the tidal waters of the Susquehanna River by ships and smaller water craft can be considered an interstate problem. These mobile sources of pollution cross State boundaries at will, discharging sewage without legal restriction, and not infrequently oil and garbage which are prohibited by law.

To the extent that salinity is considered a water quality problem, any upstream alteration of flow must be considered in terms of its downstream effect. As observed by Beaven (1946), Pritchard (1952) and others the Susquehanna River has a controlling influence on the salinity of the Chesapeake Bay, its estuaries and the lower portion of the Susquehanna River itself. In these water areas, the Atlantic Ocean mixes with fresh water from the streams draining the adjacent land surfaces. Tidal action, turbulent diffusion and currents caused by density differences between the salt and fresh waters tend to move the salt water landward up the bay. Fresh-water runoff, on the other hand, tends to push the salt water seaward down the bay. The resulting gradient of sea-water concentration along the axis of the bay depends upon the relative strength of these opposing sets of factors.

Since the Susquehanna River contributes an estimated 85% of the fresh water entering the bay, its runoff must be considered the single most important factor influencing the salinity gradient. At present, Susquehanna River runoff is effected more by the natural phenomena of floods and droughts than by upstream diversions and storage. Possibly however, future developments in the upper basin modifying streamflow may be more significant than the effects of these natural phenomena.

Intrastate Problems

Except for the interstate problems discussed in the section immediately above, the water-quality problems of the Susquehanna River drainage area can be characterized as intrastate problems. The effects of pollution from sources within the Maryland area are felt, if at all, by water users within the State of Maryland, and indeed, within the Susquehanna drainage area itself. There is no firm evidence that pollution on either side of the river affects water use on the opposite side. Similarly except for wastes dumped by mobile water craft, there are no exchanges of pollution effects between the Maryland portion of the Susquehanna River basin and Chesapeake Bay.

It is possible, however, that water quality problems (either a reduction in waste assimlative capacity or increased salinity intrusion) could result from insufficient streamflow below Conowingo Dam. Except when reduced streamflow is due to natural climatic conditions, this situation would most likely result from the combined effect of Baltimore City's diversion just above the dam and storage needs for power production at the dam site. Baltimore's diversion operations to begin in the fall of 1965 will not exceed 25 percent of the minimum daily flow (892 mgd) at the dam. Perhaps more significant is the fact that under its present license, the power company is not obligated to maintain even a minimal streamflow below the dam.

Water-Quality Control

The control of water quality in the Susquehanna River drainage area is vested in various agencies of the Federal Government, the states of New York, Pennsylvania and Maryland, and local governments. A discussion of this subject is found in the General Reference Section.

Special Water-Quality Surveys

Although the Susquehanna River is the largest of Maryland's rivers, it has been the subject of relatively little study from the standpoint of its water quality.

Schaeffer (1931) reported on studies of salinity intrusion carried out by the Maryland State Department of Health during the drought of 1930. The 1930 study was discussed earlier in this report under "natural" water-quality problems.

In recent years the Bureau of Environmental Hygiene of the Maryland State Department of Health has carried out studies of the Susquehanna River in the vicinity of the nuclear power generating station at Peach Bottom, Pennsylvania. These studies, described by Johnston and Brown (1960), sought to establish pre-operation data on environmental factors that might be affected by radioactive contaminants in the reactor effluents. Additional studies are planned for after the plant has been in operation for awhile to reveal whether any significant changes have taken place.

A study of the chemical and physical limnology of Conowingo Reservoir was conducted from April, 1959, through May, 1960 by the Chesapeake Bay Institute of The Johns Hopkins University (Whaley, 1960). The objectives of this study were to determine water movements in the reservoir in relation to inflow, outflow, wind and thermal stratification; to determine seasonal and spatial distributions of temperature, dissolved oxygen, and pH in the reservoir; to determine the organic production by aquatic plants; and to determine the oxygen balance of the reservoir.

For over 15 years, the Chesapeake Bay Institute has collected hydrographic data in the bay and its estuaries. Data collected include temperature, salinity, dissolved oxygen, turbidity, current velocity and concentration of nutrients and certain trace elements. The Institute has compiled the results of these surveys in the form of data and graphical summary reports. Findings of the Institute indicate the major influence of Susquehanna River streamflow on the bay and its many tributaries. These surveys show, for example, that the bay and its estuaries are flushed in the spring by Susquehanna River flows faster than the tributary estuaries are flushed by their own fresh-water inflow. Susquehanna streamflow was also shown to be a major factor in the distribution of nutrients.

The effect of salinity on oyster mortalities in the upper bay was studied by the Natural Resources Institute of the University of Maryland. (This research agency was formerly the State Department of Research and Education.) The investigation, as reported by Beavin (1946) indicated that the major oyster mortalities have all been associated with and are principally the direct result of low salinities caused by periods of high runoff from the Susquehanna River.

Summary on Water Quality Throughout Basin

With a few exceptions, the quality of available water supplies in the Maryland portion of the Susquehanna River basin has been generally satisfactory for most uses in the past. The nontidal streams have provided water of good chemical and physical characteristics suitable for municipal and industrial purposes after reasonable degrees of treatment.

In the tidal reach of the Susquehanna River, the intrusion of saline water from Chesapeake Bay during periods of severe drought has rendered the lower few miles of the River unsuitable as a source of public water supply. Several discharges of untreated sewage from communities along the lower main stem result in hazards to public health; however, plans have been made to correct this situation. Untreated sewage is also discharged into the tidal portion of the Susquehanna River from pleasure craft and small commercial vessels.

With no large population centers and only scattered industries in the lower Susquehanna drainage area, waste discharges have had little effect on the physical and chemical quality of the main stem. Even the tributaries, with their much smaller streamflows and dilution ratios, have not been seriously degraded by waste discharges, although there are local effects near waste outfalls.

Ground-water quality varies from good to unsatisfactory in the Susquehanna drainage area. The most prevalent natural impurity in well waters of the area is iron, found in ground waters of both the Piedmont and Coastal Plain provinces.

Saline-water intrusion is a potential factor limiting the use of ground water in the extreme lower portion of the Susquehanna basin in Maryland near the tidal portion of the main stem and also near Chesapeake Bay.

Since a relatively small portion of the state's population and industrial development are located in the Susquehanna River basin, this area has not required much attention in the past from the pollution-control agencies. With the use of water by Baltimore from the Susquehanna, the interest in this river will increase, and it can be expected that continued surveillance will be maintained by the City of Baltimore as well as by the State Department of Health and the Department of Water Resources. Protection of Maryland's interests in the water quality of the Susquehanna River requires the establishment of a permanent water-quality monitoring station on the main stem near the Pennsylvania-Maryland State boundary.

INTERSTATE ASPECTS

With the drainage area of the Susquehanna River shared by three states, the management of the water resources of this basin is necessarily an interstate matter. The Susquehanna River drains large areas in New York and Pennsylvania. Water is diverted from the Susquehanna basin in New York for use in the New York Barge Canal. The Octoraro Water Company diverts water from Octoraro Creek, a tributary of the Susquehanna River, and delivers it to four communities in the Delaware River basin in Chester County, Pennsylvania. The Chester Municipal Authority also takes water from Octoraro Creek and delivers it to the City of Chester in Delaware County, Pennsylvania, in the Delaware River basin. To date, these out-of-basin diversions have been relatively small and have not seriously affected the quantity of water available to Maryland water users in the Susquehanna basin. However, the Susquehanna River has been mentioned as a potential future source of water for Philadelphia, in the Delaware River basin (Phillips, 1961).

Although even relatively large upstream diversions would not seriously affect the quantity of water available for withdrawal purposes above Conowingo Dam in Maryland, out-of-basin diversions of water in New York or Pennsylvania might have serious consequences on the quality of water available for instream and withdrawal uses in the tidal portion of the Susquehanna River, and for instream uses in Chesapeake Bay.

It has been pointed out earlier in this report that the salinity of the bay and its sea-level arms is influenced greatly by the discharge of the Susquehanna River. Thus, any marked degree of flow regulation in that river by impoundments or diversions in New York or Pennsylvania could affect the quality, for better or worse, of the tidal waters of upper

Chesapeake Bay in Maryland.

The only state "downstream" of Maryland's portion of the Susquehanna Basin is Virginia, in which lies the southern part of Chesapeake Bay. The distance between the mouth of the Susquehanna River in Maryland and the Maryland-Virginia boundary across Chesapeake Bay is about 127 miles. Due to this distance, the time of travel, and the added dilution afforded by the many tributaries in between as well as by sea water, it is unlikely that any significant pollution in the Virginia portion of the bay could ever be traced to the Susquehanna River.

On the other hand, it might be argued that the fisheries of the Chesapeake Bay in Virginia are interdependent with those in Maryland and that the salinity and nutrient content of the entire bay is influenced by the runoff of fresh water from the Susquehanna drainage area in all three of its states - New York, Pennsylvania, and Maryland.

The interests of Virginia and Maryland in the Susquehanna River are intertwined in another way. In the event the Baltimore, District of Columbia and Washington Suburban Sanitary Commission water systems are eventually connected, such a development will probably result in the discharge into the Potomac River of waste waters originating in the Susquehanna River. This would augment fresh water flows into the estuary of the Potomac River, with effects on the salinity of that estuary. Changing the ecology of the Potomac, for better or worse, would undoubtedly influence the fisheries shared by Maryland and Virginia in the Potomac River.

The Susquehanna River has been considered as a potential source of fresh water for the State of Delaware. Engineers have suggested a tidal barrier across the northern end of Chesapeake Bay to create a shallow fresh water impoundment filled by the Susquehanna River. The plan envisions a pumping station on the eatern shore of the impoundment which would force water eastward through a pipeline across Cecil County into the State of Delaware. The advantages and disadvantages of the tidal barrier have not been reviewed, but if physically, economically, and politically feasible, the plan would add considerable fresh water to the supplies now available to Delaware. Conceivable, an interstate project could be developed to supply Susquehanna River water not only to Delaware, but also to the Eastern Shore area of Maryland.

The diversions of water into and out of the Susquehanna River basin, and water-quality aspects of interstate significance have been discussed elsewhere in this report.

Several studies, involving both Federal agencies and the three Susquehanna basin states have recently been initiated. In 1961, the Baltimore District of the Corps of Engineers was assigned the responsibility for

> providing a comprehensive plan for the development of the water and related land resources of the Susquehanna River basin...in the combined interest of flood control, navigation, water supply, recreation pollution abatement and other beneficial water uses.

The study will consist of six major sections. These are: the study of the physical and economic environment; the analysis of present and future needs for goods and services provided by water and its related land resources; the analysis of all possible solutions to fulfill these requirements; the preparation of alternative plans to fulfill the needs; the analysis of these plans and their costs and benefits; and the selection of the best plan of development.

Coordination among the participating Federal agencies and basin states is provided by a Coordinating Committee chaired by a representative of the Corps. These participants also serve on work groups and ad hoc subcommittees of the Coordinating Committee.

Separately financed but closely coordinated with the program of the Corps of Engineers is the Chesapeake Bay-Susquehanna River Basin Project of the Public Health Service. The objective of the study is to develop programs for improving and maintaining water quality for all beneficial uses to the year 2020. Cooperating with state and local agencies, the Public Health Service will prepare a series of reports covering the several sub-basins of the study area. Activities of the project to date have included the collection and tabulation of data on community water supply and waste disposal, industrial water use, water supply and waste disposal practices at Federal installations, and stream water quality; the collection of stream water-quality data through field surveys, preliminary mathematical analyses of certain of those data; and, through contract with the National Planning Association, the projection of population and economic growth.

Two project committees (one for the Chesapeake area and the other for the Susquehanna River basin) have been formed to facilitate coordination among Federal and state agencies concerned with water-quality management. Considerable data included in the Maryland Water Supply and Demand Study have been developed cooperatively with the Public Health Service Project.

The three basin states are further coordinated by an Interstate Advisory Committee with headquarters in Harrisburg, Pennsylvania. Objectives of the committee are to conduct studies on its own account, to draft an interstate compact and to safeguard the basic interests of the states while the present studies are underway.

Still another study of the Susquehanna basin now underway is being financed by 10 private electric light and power companies. According to news releases, the utilities have contracted with Battelle Memorial Institute of Columbus, Ohio to perform an economic base study of the basin and engage in research to develop an improved method for river basin analysis. The engineering firm of Tippetts-Abbett-McCarthy-Stratton of New York will assist in the survey of hydroelectric potential.

EVALUATION OF AVAILABLE DATA AND RECOMMENDATIONS FOR DATA NEEDED

The available data on water resources, water use and water quality have been evaluated for the entire State of Maryland in the General Reference Section. These general discussions for the entire State apply in varying degree to the various drainage areas into which the State is divided for the purposes of this study, including the Susquehanna River basin in Maryland.

Specific data needs should be forthcoming from the studies now underway. It is further anticipated that a permanent interstate organization will someday be created which will have a continuing function of data collection and interpretation. Future problems in the basin probably will relate more to implementing needed development rather than data collection.

SUMMARY

The Susquehanna River drainage area within the State of Maryland is generally well endowed with water resources. The main stem of the Susquehanna, the largest river along the eastern seabord of the United States, funnels into Maryland the runoff from 6,270 square miles of drainage area in the State of New York, and 20,917 square miles in the Commonwealth of Pennsylvania. Based on streamflow records at Marietta, Pennsylvania, the total runoff from the two upstream states averages about 38,000 cfs or 24.6 billion gallons a day. This includes the runoff from tributaries in Pennsylvania which join the Susquehanna downstream of the gaging station at Marietta. The 282 square miles of the basin in Maryland contribute only about 1 per cent of the 24 billion gallons per day of average runoff.

In the Piedmont province portion of the Susquehanna River drainage area in Maryland, ground water is generally available in amounts adequate for small supplies, such as for individual households, relatively small industries and commercial establishments. Darlington and the Broad Creek Scout Camp in Harford County and Rising Sun in Cecil County are the only public water systems utilizing ground water in the Piedmont province.

The Coastal Plain province within the Susquehanna River basin includes only a very small area on each side of the River near its mouth. Because of its limited area, its nearness to tidal surface water subject to salinity intrusion, and the shallow depth of its unconsolidated materials overlying the crystalline rocks, the Coastal Plain province is of little importance as a source of fresh water in the Susquehanna River basin.

The water resources of the Susquehanna River drainage area in Maryland have been developed and used only to a very limited extent. To date (1965) the most important single use of water has been the instream flow use for generation of electric energy at the Conowingo Hydroelectric Station. Several communities, the largest of which is Havre de Grace, use surface waters of the basin for public supplies. With the completion of the Susquehanna diversion system of the City of Baltimore, now under construction, that city will become the most important withdrawal user of water in the basin. Although initially the Susquehanna will only supplement Baltimore's existing sources, growth of the water-service area of the Baltimore system into the surrounding couties is expected to exert an ever-increasing demand for the diversion of Susquehanna River water into the Western Shore drainage area of Chesapeake Bay. Between Baltimore and Washington the water mains of the former are approaching those of the Washington Suburban Sanitary District in Howard County. It is not improbable that within a relatively short time, Susquehanna River water will be used in the Washington Suburban System in both the Western Shore and Potomac River drainage areas. The Susquehanna diversion project now under construction is designed to deliver 250 millions of gallons of water daily to the Baltimore system.

Next to municipal water use, the most important withdrawal category is probably rural-domestic water use. Individual households served by private ground-water systems accounted for an estimated population of about 35,000 in the Susquehanna River basin in Maryland in 1964. Based on an estimated per capita use of 75 gallons daily, these private water systems withdraw well water at a combined rate which probably does not exceed 3.0 mgd.

No recent estimates of water use for irrigation in the three-county area of the Susquehanna basin are available. However, 1957 data indicated that only about 20.6 mgd were used during the irrigation season in seven Piedmont counties of Maryland. Current (1965) use in Baltimore, Cecil and Harford Counties is estimated to be about 7.0 mgd for all purposes, and probably less than 3.0 mgd for irrigation. For those parts of these three counties which are in the Susquehanna drainage area, irrigation probably accounts for less than 1.0 mgd.

Interbasin diversions of water are known to occur in all three states of the Susquehanna River watershed, although no comprehensive inventory of such transfers of water across the watershed divide has been made. Maryland streams affected by diversions include the main stem of the Susquehanna River, Octoraro Creek, and Deer Creek. Water is diverted from Octoraro Creek in Pennsylvania for use in Chester and Delaware Counties in southeastern Pennsylvania. Permits issued by the Pennsylvania Water and Power Resources authorize two diversions totalling 31 mgd. The Aberdeen Proving Ground in Harford County diverts about 3.4 cfs (2.2 mgd) from Deer Creek. The waste waters from the Proving Ground are discharged into Chesapeake Bay. The diversion by the City of Baltimore probably will exceed all other known diversions out of the entire three-state watershed for many years. Imports of water into the Susquehanna drainage area are relatively unimportant, amounting to only a few millions of gallons daily. Only one Maryland water user, the town of Perryville in Cecil County, is known to import water into the Susquehanna basin. The waste waters from Perryville are discharged into the tidal reach of the Susquehanna River a short distance above its mouth and have no significant effect on the water economy of the basin.

Comparison of known and expected imports and exports of water indicates that the Susquehanna River watershed is and will remain a net exporter of water.

To date, there have been few serious water-quality problems in the Maryland portion of the Susquehanna River basin. The natural quality of both surface and ground water is generally good. The lower few miles of the Susquehanna River tidal estuary has been invaded by brackish water from Chesapeake Bay during extended periods of low runoff. Shallow aquifers in the vicinity of the tidal reach, if pumped heavily, would be in danger of salt-water contamination. Fresh water streams throughout the basin in Maryland are of good chemical quality.

Waste discharges into the streams have had only local effects on water quality. The diversion in Pennsylvania of water from Octoraro Creek reduces the quantity of water available to dilute and assimilate the treated sewage effluent from the town of Rising Sun in Cecil County, Maryland. The discharge of untreated sewage from Port Deposit, Havre de Grace and Perryville into the lower Susquehanna River threatens public health and lowers the value of the tidal reach of the river for recreational use; however, plans are underway to correct these situations.

It is possible, however, that water quality problems (either a reduction in waste assimlative capacity or increased salinity intrusion) could result from insufficient streamflow below Conowingo Dam. Except when reduced streamflow is due to natural climatic conditions, this situation would most likely result from the combined effect of Baltimore City's diversion just above the dam and storage needs for power production at the dam site. Baltimore's diversion operations to begin in the fall of 1965 will not exceed 25 per cent of the minimum daily flow (892 mgd) at the dam.

Perhaps more significant is the fact that under its present license, the power company is not obligated to maintain even a minimal streamflow below the dam.

Maryland's interest in the Susquehanna River basin's water resources necessarily extends upstream into New York and Pennsylvania. Although no serious problems affecting Maryland water users have been known to originate in either of the upstream states, anticipated future needs in Maryland dictate an increasing concern over the potential out-of-state developments which may affect the quantity and quality of water flowing downstream. The interstate nature of the Susquehanna necessitates cooperation among the basin states both to protect individual state interests as well as to achieve some optimal pattern of development. Cooperation can best be achieved by an interstate organization capable of viewing and planning for the basin as a single entity rather than parts of three different political jurisdictions. The interstate compact now being drafted by the Interstate Advisory Committee of the Susquehanna River Basin will establish such an organization.

In Maryland, a recent reorganization of the State's water agencies included the creation of a Department of Water Resources which is assigned many of the activities heretofore carried out by several agencies. The Department of Water Resources is specifically charged with the responsibility of carrying out comprehensive planning studies for each basin in the State. These studies will not only guide future management and development of water resources in Maryland but will also provide the necessary supporting data for amending existing regularory legislation which at present is a constraint on the Department's operation.

This study has been restricted in scope largely to the small part of the Susquehanna basin in Maryland.

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APPENDIX A

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

See Description of Appendices (Appendix A) in the General Reference Section for a narrative discussion of this material.

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER*	___/Head of Susquehanna River
SUSQUEHANNA RIVER	___/Gaging Station, McCalls Ferry, Pa.(D.A.26,800)
SUSQUEHANNA RIVER	___/Dam near McCalls Ferry, Pa.
SUSQUEHANNA RIVER**	47.7/Upstream boundary of Boro of Marietta, Lancaster County, Pa.
SUSQUEHANNA RIVER	46.3/Downstream boundary of Boro of Marietta, Lancaster County, Pa.
SUSQUEHANNA RIVER	45.9/Gaging Station at Marietta, Pa.(D.A. 28,873)
SUSQUEHANNA RIVER	45.8/Mouth of Big Chickies Creek (D.A. 25,860)
Big Chickies Creek	___/Head of Big Chickies Creek in Lancaster County, Pa.
Big Chickies Creek	0.0/Mouth of Big Chickies Creek (D.A. 127.4)
SUSQUEHANNA RIVER	45.8/Mouth of Big Chickies Creek (D.A. 25,990)
SUSQUEHANNA RIVER	44.6/Upstream boundary of Boro of Columbia, Lancaster County, Pa.
SUSQUEHANNA RIVER	44.4/Upstream boundary of Boro of Wrightsville, York County, Pa.
SUSQUEHANNA RIVER	44.1/Pa. R.R. Bridge at Wrightsville, Pa.
SUSQUEHANNA RIVER	44.0/Bridge at U.S. #30 at Columbia, Pa.
SUSQUEHANNA RIVER	43.7/Mouth of Kreutz Creek
Kreutz Creek	___/Head of Kreutz Creek
Kreutz Creek	0.0/Mouth of Kreutz Creek (D.A. 34.4)
SUSQUEHANNA RIVER	43.7/Mouth of Kreutz Creek
SUSQUEHANNA RIVER	43.4/Downstream boundary of Boro of Wrightsville, York County, Pa.
SUSQUEHANNA RIVER	43.0/Mouth of Shawnee Run
Shawnee Run	2.8/Head of Shawnee Run
Shawnee Run	0.0/Mouth of Shawnee Run
SUSQUEHANNA RIVER	43.0/Mouth of Shawnee Run
SUSQUEHANNA RIVER	42.8/Mouth of Strickler Run
Strickler Run	4.1/Head of Strickler Run
Strickler Run	0.0/Mouth of Strickler Run (D.A. 6.1)
SUSQUEHANNA RIVER	42.8/Mouth of Strickler Run
SUSQUEHANNA RIVER	42.7/Downstream boundary of Boro of Columbia, Lancaster, Pa.
SUSQUEHANNA RIVER	41.2/Mouth of Shumans Run
Shumans Run	0.9/Head of Shumans Run
Shumans Run	0.0/Mouth of Shumans Run
SUSQUEHANNA RIVER	41.2/Mouth of Shumans Run
SUSQUEHANNA RIVER	40.7/Mouth of Stamans Run
Stamans Run	2.6/Head of Stamans Run
Stamans Run	0.0/Mouth of Stamans Run
SUSQUEHANNA RIVER	40.7/Mouth of Stamans Run
SUSQUEHANNA RIVER	40.6/Mouth of Klines Run
Klines Run	1.5/Head of Klines Run
Klines Run	0.0/Mouth of Klines Run
SUSQUEHANNA RIVER	40.6/Mouth of Klines Run
SUSQUEHANNA RIVER	40.1/Mouth of Dry Run
Dry Run	1.2/Head of Dry Run
Dry Run	0.0/Mouth of Dry Run
SUSQUEHANNA RIVER	40.1/Mouth of Dry Run

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER	39.8/Mouth of Witmers Run
Witmers Run	1.4/Head of Witmers Run
Witmers Run	0.0/Mouth of Witmers Run
SUSQUEHANNA RIVER	39.8/Mouth of Witmers Run
SUSQUEHANNA RIVER	39.8/Mouth of Canadochly Creek(also known as Shrontz Creek)
Canadochly Creek	3.4/Head of Canadochly Creek
Canadochly Creek	0.0/Mouth of Canadochly Creek (D.A. 3.3)
SUSQUEHANNA RIVER	39.8/Mouth of Canadochly Creek
SUSQUEHANNA RIVER	39.6/Mouth of Cabin Creek
Cabin Creek	10.9/Head of Cabin Creek
Cabin Creek	0.0/Mouth of Cabin Creek (D.A. 14.2)
SUSQUEHANNA RIVER	39.6/Mouth of Cabin Creek
SUSQUEHANNA RIVER	39.0/Mouth of Wisslers Run
Wisslers Run	1.4/Head of Wisslers Run
Wisslers Run	0.0/Mouth of Wisslers Run (D.A. 0.7)
SUSQUEHANNA RIVER	39.0/Mouth of Wisslers Run
SUSQUEHANNA RIVER	38.8/Mouth of Bull Run
Bull Run	1.3/Head of Bull Run
Bull Run	0.0/Mouth of Bull Run (D.A. 0.7)
SUSQUEHANNA RIVER	38.8/Mouth of Bull Run
SUSQUEHANNA RIVER	38.4/Mouth of Fishing Creek
Fishing Creek	11.3/Head of Fishing Creek
Fishing Creek	0.0/Mouth of Fishing Creek (D.A. 18.9)
SUSQUEHANNA RIVER	38.4/Mouth of Fishing Creek
SUSQUEHANNA RIVER	37.4/Mouth of Green Branch
Green Branch	2.4/Head of Green Branch
Green Branch	0.0/Mouth of Green Branch (D.A. 1.7)
SUSQUEHANNA RIVER	37.4/Mouth of Green Branch
SUSQUEHANNA RIVER	37.2/Mouth of Manns Run
Manns Run	1.4/Head of Manns Run
Manns Run	0.0/Mouth of Manns Run (D.A. 0.7)
SUSQUEHANNA RIVER	37.2/Mouth of Manns Run
SUSQUEHANNA RIVER	37.1/Mouth of Mahala Run
Mahala Run	0.6/Head of Mahala Run
Mahala Run	0.0/Mouth of Mahala Run
SUSQUEHANNA RIVER	37.1/Mouth of Mahala Run
SUSQUEHANNA RIVER	36.1/Mouth of Fisherman Run
Fisherman Run	1.0/Head of Fisherman Run
Fisherman Run	0.0/Mouth of Fisherman Run
SUSQUEHANNA RIVER	36.1/Mouth of Fisherman Run
SUSQUEHANNA RIVER	36.0/Mouth of Cuffs Run
Cuffs Run	1.0/Head of Cuffs Run
Cuffs Run	0.0/Mouth of Cuffs Run
SUSQUEHANNA RIVER	36.0/Mouth of Cuffs Run
SUSQUEHANNA RIVER	35.5/Mouth of Frys Run
Frys Run	0.6/Head of Frys Run
Frys Run	0.0/Mouth of Frys Run
SUSQUEHANNA RIVER	35.5/Mouth of Frys Run

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER	34.0/Mouth of Wilson Run
Wilson Run	1.4/Head of Wilson Run
Wilson Run	0.0/Mouth of Wilson Run
SUSQUEHANNA RIVER	34.0/Mouth of Wilson Run
SUSQUEHANNA RIVER	33.6/Safe Harbor Dam and Hydroelectric Power Plant
SUSQUEHANNA RIVER	33.3/Mouth of Conestoga Creek
Conestoga Creek	___/Head of Conestoga Creek
Conestoga Creek	___/Gaging Station at Lancaster Pa. (D.A.324)
Conestoga Creek	0.0/Mouth of Conestoga Creek (D.A. 474.8)
SUSQUEHANNA RIVER	33.3/Mouth of Conestoga Creek
SUSQUEHANNA RIVER	33.28/Mouth of Boyds Run
Boyds Run	0.5/Head of Boyds Run
Boyds Run	0.0/Mouth of Boyds Run
SUSQUEHANNA RIVER	33.28/Mouth of Boyds Run
SUSQUEHANNA RIVER	32.3/Mouth of Grubb Hollow
Grubb Hollow	1.6/Head of Grubb Hollow
Grubb Hollow	0.0/Mouth of Grubb Hollow
SUSQUEHANNA RIVER	32.3/Mouth of Grubb Hollow
SUSQUEHANNA RIVER	31.0/Mouth of Pequea Creek
Pequea Creek	___/Head of Pequea Creek in Lancaster County,P
Pequea Creek	14.4/Bridge, Pennsylvania R.R.
Pequea Creek	14.3/Mouth of Big Beaver Creek
Big Beaver Creek	___/Head of Big Beaver Creek
Big Beaver Creek	0.0/Mouth of Big Beaver Creek
Pequea Creek	14.3/Mouth of Big Beaver Creek
Pequea Creek	13.8/Bridge, Pennsylvania Highway #72
Pequea Creek	13.5/Mouth of Huber Run
Huber Run	___/Head of Huber Run
Huber Run	0.0/Mouth of Huber Run
Pequea Creek	13.5/Mouth of Huber Run
Pequea Creek	9.1/Bridge, Pa. Highway #324
Pequea Creek	9.0/Mouth of Goads Run
Goads Run	3.9/Head of Goads Run
Goads Run	0.0/Mouth of Goads Run
Pequea Creek	9.0/Mouth of Goads Run
Pequea Creek	7.6/Mouth of Silver Mine Run
Silver Mine Run	1.5/Head of Silver Mine Run
Silver Mine Run	0.0/Mouth of Silver Mine Run
Pequea Creek	7.6/Mouth of Silver Mine Run
Pequea Creek	4.7/Mouth of Climbers Run
Climbers Run	3.0/Head of Climbers Run
Climbers Run	2.7/Bridge, Pennsylvania R.R.
Climbers Run	1.6/Mouth of Trout Run
Trout Run	3.2/Head of Trout Run
Trout Run	0.0/Mouth of Trout Run
Climbers Run	1.6/Mouth of Trout Run
Climbers Run	0.4/Bridge, Pennsylvania Highway #324
Climbers Run	0.0/Mouth of Climbers Run
Pequea Creek	4.7/Mouth of Climbers Run
Pequea Creek	3.5/Bridge, Pennsylvania R.R.

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Pequea Creek	3.3/Pennsylvania Highway #324
Pequea Creek	0.1/Bridge, Secondary Road
Pequea Creek	0.05/Bridge, Pennsylvania R.R.
Pequea Creek	0.0/Mouth of Pequea Creek (D.A. 153.4)
SUSQUEHANNA RIVER	31.0/Mouth of Pequea Creek
SUSQUEHANNA RIVER	30.4/Mouth of Otter Creek
Otter Creek	11.5/Head of Otter Creek
Otter Creek	0.0/Mouth of Otter Creek (D.A. 19.3)
SUSQUEHANNA RIVER	30.4/Mouth of Otter Creek
SUSQUEHANNA RIVER	30.1/Mouth of Sawmill Run
Sawmill Run	2.4/Head of Sawmill Run
Sawmill Run	0.0/Mouth of Sawmill Run (D.A. 4.3)
SUSQUEHANNA RIVER	30.1/Mouth of Sawmill Run
SUSQUEHANNA RIVER	29.6/Mouth of House Rock Run
House Rock Run	0.3/Head of House Rock Run
House Rock Run	0.0/Mouth of House Rock Run
SUSQUEHANNA RIVER	29.6/Mouth of House Rock Run
SUSQUEHANNA RIVER	29.1/Mouth of Brubaker Run
Brubaker Run	0.2/Head of Brubaker Run
Brubaker Run	0.0/Mouth of Brubaker Run
SUSQUEHANNA RIVER	29.1/Mouth of Brubaker Run
SUSQUEHANNA RIVER	28.8/Mouth of Reed Run
Reed Run	0.7/Head of Reed Run
Reed Run	0.0/Mouth of Reed Run
SUSQUEHANNA RIVER	28.8/Mouth of Reed Run
SUSQUEHANNA RIVER	28.4/Mouth of Counselman Run
Counselman Run	1.7/Head of Counselman Run
Counselman Run	0.0/Mouth of Counselman Run
SUSQUEHANNA RIVER	28.4/Mouth of Counselman Run
SUSQUEHANNA RIVER	28.2/Mouth of Tucquan Creek
Tucquan Creek	5.8/Head of Tucquan Creek
Tucquan Creek	0.0/Mouth of Tucquan Creek (D.A. 6.4)
SUSQUEHANNA RIVER	28.2/Mouth of Tucquan Creek
SUSQUEHANNA RIVER	27.7/Mouth of Duncan Run
Duncan Run	1.7/Head of Duncan Run
Duncan Run	0.0/Mouth of Duncan Run
SUSQUEHANNA RIVER	27.7/Mouth of Duncan Run
SUSQUEHANNA RIVER	27.0/Mouth of Oakland Run
Oakland Run	3.2/Head of Oakland Run
Oakland Run	0.0/Mouth of Oakland Run (D.A. 3.3)
SUSQUEHANNA RIVER	27.0/Mouth of Oakland Run
SUSQUEHANNA RIVER	26.5/Mouth of Kellys Run
Kellys Run	2.4/Head of Kellys Run
Kellys Run	0.0/Mouth of Kellys Run (D.A. 1.9)
SUSQUEHANNA RIVER	26.5/Mouth of Kellys Run
SUSQUEHANNA RIVER	26.0/Mouth of Tobe Run
Tobe Run	0.6/Head of Tobe Run
Tobe Run	0.0/Mouth of Tobe Run
SUSQUEHANNA RIVER	26.0/Mouth of Tobe Run

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER	25.9/Holtwood Dam and Power Plant, Holtwood, Pa.
SUSQUEHANNA RIVER	25.0/Mouth of Anderson Run
Anderson Run	2.1/Head of Anderson Run
Anderson Run	0.0/Mouth of Anderson Run
SUSQUEHANNA RIVER	25.0/Mouth of Anderson Run
SUSQUEHANNA RIVER	23.8/Mouth of Muddy Run
Muddy Run	6.1/Head of Muddy Run
Muddy Run	0.5/Dam Site for proposed pumped-storage hydroelectric power project
Muddy Run	0.0/Mouth of Muddy Run (D.A. 9.4)
SUSQUEHANNA RIVER	23.8/Mouth of Muddy Run
SUSQUEHANNA RIVER	23.2/Mouth of Wissler Run
Wissler Run	2.1/Head of Wissler Run near Liberty Square, Lancaster County, Pa.
Wissler Run	0.0/Mouth of Wissler Run
SUSQUEHANNA RIVER	23.2/Mouth of Wissler Run
SUSQUEHANNA RIVER	22.6/Mouth of Muddy Creek
Muddy Creek	15.9/Head of Muddy Creek at Muddy Creek Forks, York County, Pennsylvania
Muddy Creek	7.5/Mouth of Fishing Creek
Fishing Creek	5.5/Head of Fishing Creek near Fawn Grove, York County, Pennsylvania
Fishing Creek	2.5/Bridge, Pa. Highway #851
Fishing Creek	0.7/Mouth of Neill Run
Neill Run	6.2/Head of Neill Run near Fawn Grove, York County, Pennsylvania
Neill Run	0.0/Mouth of Neill Run near Castle Fin, Pennsylvania (D.A. 5.7)
Fishing Creek	0.7/Mouth of Neill Run
Fishing Creek	0.0/Mouth of Fishing Creek (D.A. 12.0)
Muddy Creek	7.5/Mouth of Fishing Creek
Muddy Creek	7.4/Bridge, Md. & Pa. R.R.
Muddy Creek	6.9/Mouth of Scott Creek, Pa.
Scott Creek	3.3/Head of Scott Creek near Cardiff, Harford County, Maryland
Scott Creek	3.3/Outfall, Maryland Green Marble Co., Md.
Scott Creek	3.3/Outfall, Whiteford Packing Company
Scott Creek	3.2/State and County line Upstream - Harford County, Md. Downstream, York, Pa.
Scott Creek	2.2/Bridge, Md. & Pa. R.R.
Scott Creek	1.9/Bridge, Md. & Pa. R.R.
Scott Creek	1.2/Bridge, Md. & Pa. R.R.
Scott Creek	0.9/Bridge, Md. & Pa. R.R.
Scott Creek	0.5/Bridge, Pa. Highway #851
Scott Creek	0.3/Bridge, Md. & Pa. R.R.
Scott Creek	0.0/Mouth of Scott Creek (D.A. 5.4)
Muddy Creek	6.9/Mouth of Scott Creek
Muddy Creek	4.9/Bridge, Pa. Highway #74 at Castle Fin, York County, Pa.

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Muddy Creek	3.5/Bridge, Secondary road near Castle Fin, York County, Pennsylvania
Muddy Creek	3.4/Gaging Station at Castle Fin, Pa.
Muddy Creek	0.0/Mouth of Muddy Creek (D.A. 138.7)
SUSQUEHANNA RIVER	22.6/Mouth of Muddy Creek
SUSQUEHANNA RIVER	21.5/Village of Fishing Creek, Lancaster Co., Pa.
SUSQUEHANNA RIVER	21.4/Mouth of Fishing Creek
Fishing Creek	___/Head of Fishing Creek
Fishing Creek	0.1/Bridge, Pa. R.R.
Fishing Creek	0.0/Mouth of Fishing Creek (D.A. 14.6)
SUSQUEHANNA RIVER	21.4/Mouth of Fishing Creek
SUSQUEHANNA RIVER	21.2/Mouth of Robinson Run
Robinson Run	1.4/Head of Robinson Run
Robinson Run	0.0/Mouth of Robinson Run
SUSQUEHANNA RIVER	21.2/Mouth of Robinson Run
SUSQUEHANNA RIVER	20.2/Village of Venton, Lancaster County, Pa.
SUSQUEHANNA RIVER	20.1/Village of Muscovy Beach, York County, Pa.
SUSQUEHANNA RIVER	19.9/Intake, Peach Bottom Atomic Power Station, Philadelphia Electric Co.
SUSQUEHANNA RIVER	19.4/Village of Peach Bottom
SUSQUEHANNA RIVER	18.5/Mouth of Peters Creek
Peters Creek	5.4/Head of Peters Creek near Hensel, Pa.
Peters Creek	0.8/Mouth of Puddle Duck Creek
Puddle Duck Creek	3.7/Head of Puddle Duck Creek
Puddle Duck Creek	0.0/Mouth of Puddle Duck Creek
Peters Creek	0.8/Mouth of Puddle Duck Creek
Peters Creek	0.1/Bridge, Pa. R.R.
Peters Creek	0.0/Mouth of Peters Creek (D.A. 10.6)
SUSQUEHANNA RIVER	18.5/Mouth of Peters Creek
SUSQUEHANNA RIVER	17.0/Mouth of Haines Branch
Haines Branch	1.7/Head of Haines Branch
Haines Branch	0.0/Mouth of Haines Branch
SUSQUEHANNA RIVER	17.0/Mouth of Haines Branch
SUSQUEHANNA RIVER	16.5/Mouth of Michael Run
Michael Run	4.0/Head of Michael Run
Michael Run	0.0/Mouth of Michael Run
SUSQUEHANNA RIVER	16.5/Mouth of Michael Run
SUSQUEHANNA RIVER	16.3/State and County line Upstream - York and Lancaster Counties, Pa. Downstream - Harford and Cecil Counties, Md.
SUSQUEHANNA RIVER***	15.1/Mouth of Broad Creek
Broad Creek	17.3/Head of Broad Creek near Constitution, Harford County, Md.
Broad Creek	15.8/Bridge, Whiteford Road
Broad Creek	15.1/Bridge, Wheeler School Road
Broad Creek	14.4/Bridge, Md. Highway #624 (Graceton Road)
Broad Creek	13.3/Bridge, Jenkins Road at Pylesville, Md.
Broad Creek	13.25/Bridge, Md. & Pa. R.R.
Broad Creek	13.2/Town of Pylesville

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway)						LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway)					
1	2	3	4	5	6	1	2	3	4	5	6
	Broad Creek						13.2/Bridge, Md. Highway #165 (Pylesville Road)				
	Broad Creek						13.1/Gaging Station at Pylesville, Md. (D.A. 3.96)				
	Broad Creek						12.9/Mouth of Jacks Hole Run				
		Jacks Hole Run						2.9/Head of Jacks Hole Run			
		Jacks Hole Run						2.4/Bridge, Md. Highway #24 (Rocks Road)			
		Jacks Hole Run						1.2/Bridge, Md. Highway #624(Graccton Rd.)			
		Jacks Hole Run						0.15/Bridge, Md. and Pa. R.R.			
		Jacks Hole Run						0.1/Bridge, Md. Highway #165			
		Jacks Hole Run						0.0/Mouth of Jacks Hole Run			
	Broad Creek						12.9/Mouth of Jacks Hole Run				
	Broad Creek						12.4/Bridge, Ridge Road				
	Broad Creek						11.8/Bridge, Heaps School Road				
	Broad Creek						11.1/Bridge, Heaps Road				
	Broad Creek						9.9/Bridge, Taylor Road				
	Broad Creek						9.1/Bridge, Md. Highway #646 (Prospect Road)				
	Broad Creek						9.0/Outfall, Western Md. Dairy, Pylesville				
	Broad Creek						8.7/Gaging Station, Mill Green, Md. (D.A. 16.4)				
	Broad Creek						8.7/Bridge, Secondary Road at Mill Green				
	Broad Creek						7.6/Bridge, Macton Rd. near Mill Green				
	Broad Creek						5.6/Bridge, Md. Highway #136 (Whiteford Road)				
	Broad Creek						4.9/Bridge, Robinson Mill Road				
	Broad Creek						3.5/Dam at Broad Creek Memorial Scout Camp, Harford County, Md.				
	Broad Creek						3.2/Mouth of Deep Creek				
		Deep Creek						5.4/Head of Deep Creek			
		Deep Creek						3.9/Bridge, Kerr Road			
		Deep Creek						3.5/Bridge, Md. Highway #646 (Prospect Rd.)			
		Deep Creek						2.2/Bridge, Little Road			
		Deep Creek						1.9/Bridge, Deep Run Road			
		Deep Creek						1.4/Bridge, Peach Orchard Road			
		Deep Creek						1.0/Intake, Broad Creek Memorial Scout Camp, Boy Scouts of America, Baltimore Area Council			
		Deep Creek						0.7/Bridge, Susquehanna Hall Road			
		Deep Creek						0.0/Mouth of Deep Creek			
	Broad Creek						3.2/Mouth of Deep Creek				
	Broad Creek						1.0/Bridge, Md. Highway #623 (Flintville Rd.)				
	Broad Creek						0.0/Mouth of Broad Creek (D.A. 41.4)				
SUSQUEHANNA RIVER						15.1/Mouth of Broad Creek					
SUSQUEHANNA RIVER						12.9/Mouth of Conowingo Creek					
	Conowingo Creek						___/Head of Conowingo Creek in Lancaster County, Pa.				
	Conowingo Creek						4.7/Bridge, Secondary road near Pleasant Grove, Pa.				
	Conowingo Creek						4.2/State and County Line Upstream - Lancaster County, Pa. Downstream - Cecil County, Md. (D.A. 33.9)				

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Conowingo Creek	2.4/Intake - Girl Scout Camp, east of Pilot, Md.
Conowingo Creek	2.0/Bridge, Secondary road near Oakwood
Conowingo Creek	0.2/Bridge, Ball Manor Road
Conowingo Creek	0.01/Bridge, Pa. R.R.
Conowingo Creek	0.0/Mouth of Conowingo Creek (D.A. 38.6)
SUSQUEHANNA RIVER	12.9/Mouth of Conowingo Creek
SUSQUEHANNA RIVER	12.5/Mouth of Peddler Run
Peddler Run	5.2/Head of Peddler Run near Dublin, Md.
Peddler Run	5.1/Bridge, Hughes Road
Peddler Run	4.6/Bridge, Dublin Road
Peddler Run	2.7/Bridge, Glen Cove Road
Peddler Run	1.3/Bridge, Castleton Road
Peddler Run	0.0/Mouth of Peddler Run
SUSQUEHANNA RIVER	12.5/Mouth of Peddler Run
SUSQUEHANNA RIVER	11.6/Hopkins Cove, Harford County, Md.
SUSQUEHANNA RIVER	10.9/Intake, Conowingo, Md. (Intake above dam)
SUSQUEHANNA RIVER	10.9/Conowingo Dam (D.A. 27,098)
SUSQUEHANNA RIVER	10.9/Bridge, U.S.Highway #1 at Conowingo Dam
SUSQUEHANNA RIVER	10.9/Outfall, Conowingo, Md. (Outfall below dam)
SUSQUEHANNA RIVER	10.6/Upstream end of Rowland Island
SUSQUEHANNA RIVER	10.4/Downstream end of Rowland Island
SUSQUEHANNA RIVER	10.2/Mouth of Octoraro Creek
Octoraro Creek	___/Head of Octoraro Creek in Pa.
Octoraro Creek	___/Intake, Chester, Pa.
Octoraro Creek	9.3/Dam, impounding Pine Grove Reservoir
Octoraro Creek	9.3/State and County Line, Upstream - Lancaster and Chester Counties, Pa. Downstream - Cecil County, Md.
Octoraro Creek	8.4/State and County Line, Upstream - Cecil County, Md. Downstream - Chester County, Pa.
Octoraro Creek	8.1/State and County Line, Upstream - Chester County, Pa. Downstream - Cecil County, Md. (D.A. 176)
Octoraro Creek	6.5/Mouth of Stone Run
Stone Run	5.5/Head of Stone Run in Pa.
Stone Run	___/Mouth of Buckleys Creek
Buckleys Creek	___/Head of Buckleys Creek
Buckleys Creek	0.0/Mouth of Buckleys Creek
Stone Run	___/Mouth of Buckleys Creek
Stone Run	5.4/State and County Line, Upstream - Chester County, Pa. Downstream - Cecil County, Md.
Stone Run	4.8/Bridge, Little New York Road
Stone Run	4.6/Bridge, Stevens Road
Stone Run	3.2/Bridge, Red Pump Road

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Stone Run	2.0/Outfall Western Md. Dairy
Stone Run	2.0/Outfall, Rising Sun, Md.
Stone Run	1.3/Bridge, Slicers Mill Road
Stone Run	0.1/Bridge, Boy Scout Road
Stone Run	0.0/Mouth of Stone Run
Octoraro Creek	6.5/Mouth of Stone Run
Octoraro Creek	4.2/Bridge, U.S. Highway #1 and Md. #273
Octoraro Creek	3.9/Mouth of Love Run
Love Run	3.1/Head of Love Run near West Nottingham, Md.
Love Run	2.8/Bridge, Pa. R.R.
Love Run	2.6/Bridge, Nesbitt Road
Love Run	0.1/Bridge, Md. Highway #591
Love Run	0.0/Mouth of Love Run
Octoraro Creek	3.9/Mouth of Love Run
Octoraro Creek	3.5/Bridge, Md. Highway #591
Octoraro Creek	3.5/Gaging Station, Rising Sun, Md. (D.A. 191.0
Octoraro Creek	1.0/Mouth of Basin Run
Basin Run	4.3/Head of Basin Run
Basin Run	3.0/Bridge, Lipencott Road
Basin Run	3.0/Outfall, J. Wm. Liddell Co.
Basin Run	3.0/Outfall, Silver Canning Co.
Basin Run	3.0/Gaging Station, Liberty Grove, Md. (D.A. 5.31)
Basin Run	2.8/Bridge, U.S. Government R.R.
Basin Run	2.7/Bridge, Pa. R.R.
Basin Run	2.6/Bridge, Pa. R.R.
Basin Run	2.2/Bridge, Groff Road
Basin Run	2.0/Bridge, Md. Highway #269
Basin Run	1.7/Bridge, Pa. R.R.
Basin Run	1.3/Bridge, Pa. R.R.
Basin Run	0.9/Bridge, Groff Road
Basin Run	0.4/Bridge, Pa. R.R.
Basin Run	0.4/Bridge, Groff Road
Basin Run	0.1/Bridge, McCauley Road
Basin Run	0.0/Mouth of Basin Run
Octoraro Creek	1.0/Mouth of Basin Run
Octoraro Creek	1.0/Bridge, Md. Highway #338
Octoraro Creek	1.0/Gaging Station at Rowlandsville (D.A. 217)
Octoraro Creek	0.8/Bridge, Pa. R.R.
Octoraro Creek	0.6/Bridge, Pa. R.R.
Octoraro Creek	0.5/Bridge, Pa. R.R.
Octoraro Creek	0.3/Bridge, U.S. Highway #222
Octoraro Creek	0.0/Mouth of Octoraro Creek (D.A. 209.9)
SUSQUEHANNA RIVER	10.2/Mouth of Octoraro Creek
SUSQUEHANNA RIVER	7.6/Mouth of Deer Creek
Deer Creek	___/Head of Deer Creek in Pa.
Deer Creek	44.3/State and County Line, Upstream - York County, Pa. Downstream - Baltimore Co., Md. (D.A. 12.3

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway 1 2 3 4 5 6
Deer Creek	43.7/Bridge, Harris Mill Road
Deer Creek	43.3/Mouth of Harris Mill Creek
Harris Mill Creek	3.1/Head of Harris Mill Creek
Harris Mill Creek	1.6/Bridge, Harris Mill Road
Harris Mill Creek	1.5/Mouth of Little Deer Creek
Little Deer Creek	1.6/Head of Little Deer Creek in Pa.
Little Deer Creek	0.9/State and County Line Upstream - York Co., Pa. Downstream - Baltimore Co., Md.
Little Deer Creek	___/Mouth of Unnamed Ditch
Unnamed Ditch	___/Head of Unnamed Ditch
Unnamed Ditch	0.25/Outfall, Krout and Shaffer
Unnamed Ditch	0.0/Mouth of Unnamed Ditch
Little Deer Creek	___/Mouth of Unnamed Ditch
Little Deer Creek	0.0/Mouth of Little Deer Creek
Harris Mill Creek	1.5/Mouth of Little Deer Creek
Harris Mill Creek	1.2/Bridge, Harris Mill Road
Harris Mill Creek	0.9/Bridge, Dunk Freeland Road
Harris Mill Creek	0.0/Mouth of Harris Mill Creek
Deer Creek	43.3/Mouth of Harris Mill Creek
Deer Creek	42.5/Mouth of Ebaughs Creek
Ebaughs Creek	___/Head of Ebaughs Creek, in Pa.
Ebaughs Creek	1.4/State and County Line, Upstream - York County, Pa. Downstream - Baltimore Co., Md.
Ebaughs Creek	0.1/Bridge, Harris Mill Road
Ebaughs Creek	0.0/Mouth of Ebaughs Creek
Deer Creek	42.5/Mouth of Ebaughs Creek
Deer Creek	42.4/Bridge, Bond Road
Deer Creek	42.3/Bridge West Liberty Road
Deer Creek	40.7/County Line, Upstream - Balto. Downstream - Harford
Deer Creek	39.9/Bridge, Green Road
Deer Creek	38.6/Mouth of Plumtree Branch
Plumtree Branch	3.0/Head of Plumtree Branch
Plumtree Branch	2.2/Bridge, Openshaw Road
Plumtree Branch	1.8/Bridge, Openshaw Road
Plumtree Branch	1.5/Bridge, Kirkwood Shop Road
Plumtree Branch	0.7/County Line, Upstream - Balto. Downstream - Harford
Plumtree Branch	0.0/Mouth Plumtree Branch
Deer Creek	38.6/Mouth of Plumtree Branch
Deer Creek	38.2/Bridge, Jolly Acres Road
Deer Creek	37.2/Bridge, Norrisville Road, Md. Highway #23
Deer Creek	36.9/Mouth of Jackson Branch
Jackson Branch	2.2/Head of Jackson Branch
Jackson Branch	0.6/Bridge, Ayers Chapel Road
Jackson Branch	0.1/Bridge, Harford Creamery Road
Jackson Branch	0.0/Mouth of Jackson Branch

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Deer Creek	36.9/Mouth of Jackson Branch
Deer Creek	34.8/Bridge, Amos Road
Deer Creek	32.8/Bridge, Madonna Road
Deer Creek	32.5/Mouth of Island Branch
Island Branch	4.7/Head of Island Branch near Wiley, Pa.
Island Branch	4.6/State and County Line Upstream - York County, Pa. Downstream - Harford County, Md.
Island Branch	4.1/Bridge, New Park Road
Island Branch	3.5/Bridge, Harkins Road
Island Branch	2.9/Bridge, Amos Mill Road
Island Branch	2.8/Bridge, Amos Road
Island Branch	2.4/Bridge, Carea Road
Island Branch	0.1/Bridge, Telegraph Road
Island Branch	0.0/Mouth of Island Branch
Deer Creek	32.5/Mouth of Island Branch
Deer Creek	29.5/Mouth of Big Branch
Big Branch	6.0/Head of Big Branch
Big Branch	5.6/Bridge Carea Road
Big Branch	4.6/State and County Line Upstream - York County, Pa. Downstream - Harford County, Md.
Big Branch	4.2/Bridge, Channel Road
Big Branch	3.1/Bridge, West Heaps Road
Big Branch	2.8/Bridge, Neal Road
Big Branch	1.9/Bridge, Harkins Road
Big Branch	0.2/Bridge, Eden Mill Road
Big Branch	0.0/Mouth of Big Branch
Deer Creek	29.5/Mouth of Big Branch
Deer Creek	29.2/Bridge, Fawn Grove Road, Md. Hwy. #163
Deer Creek	28.9/Mouth of Falling Branch
Falling Branch	5.2/Head of Falling Branch
Falling Branch	5.0/State and County Line, Upstream - York County, Pa. Downstream - Harford County, Md.
Falling Branch	4.2/Bridge, McDermott Road
Falling Branch	2.8/Bridge, Linkous Road
Falling Branch	2.2/Bridge, Md. Highway #517 (Harkins Rd)
Falling Branch	1.5/Bridge, Falling Branch Road
Falling Branch	1.0/Bridge, Falling Branch Road
Falling Branch	0.1/Bridge, Red Bridge Road
Falling Branch	0.0/Mouth of Falling Branch
Deer Creek	28.9/Mouth of Falling Branch
Deer Creek	28.2/Bridge, Federal Hill Rd., Md. Highway #165
Deer Creek	27.8/Mouth of Little Deer Creek
Little Deer Creek	7.4/Head of Little Deer Creek
Little Deer Creek	6.3/Bridge, Lemon Road
Little Deer Creek	4.1/Mouth of Cattail Branch
Cattail Branch	2.5/Head of Cattail Branch
Cattail Branch	2.1/Bridge, Cox Road

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway)						LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
1	2	3	4	5	6	
			Cattail Branch			1.0/Bridge, Nelson Mill Road
			Cattail Branch			0.2/Bridge, Madonna Road
			Cattail Branch			0.0/Mouth of Cattail Branch
		Little Deer Creek				4.1/Mouth of Cattail Branch
		Little Deer Creek				4.0/Bridge, Madonna Road
		Little Deer Creek				3.4/Bridge, Mt. Horeb Road
		Little Deer Creek				0.6/Bridge, Md. Highway #165 (Federal Hill)
		Little Deer Creek				0.0/Mouth of Little Deer Creek
	Deer Creek					27.8/Mouth of Little Deer Creek
	Deer Creek					27.2/Mouth of Rock Hollow Branch
		Rock Hollow Branch				2.6/Head of Rock Hollow Branch near Federal Hill, Md.
		Rock Hollow Branch				0.2/Bridge, St. Clair Bridge Road
		Rock Hollow Branch				0.0/Mouth of Rock Hollow Branch
	Deer Creek					27.2/Mouth of Rock Hollow Branch
	Deer Creek					27.1/Bridge, Md. Highway #651
	Deer Creek					26.6/Mouth of Wet Stone Branch
		Wet Stone Branch				4.9/Head of Wet Stone Branch
		Wet Stone Branch				0.0/Mouth of Wet Stone Branch
	Deer Creek					26.6/Mouth of Wet Stone Branch
	Deer Creek					26.3/Bridge, St. Clair Bridge Road, Md. Highway #651
	Deer Creek					24.5/Bridge, Md. Highway #24 (Rocks Road)
	Deer Creek					24.2/Mouth of Gladden Branch
		Gladden Branch				1.3/Head of Gladden Branch
		Gladden Branch				0.3/Bridge, Md. & Pa. R.R.
		Gladden Branch				0.0/Mouth of Gladden Branch
	Deer Creek					24.2/Mouth of Gladden Branch
	Deer Creek					24.0/Gaging Station at Rocks Md., (D.A. 92.1) (Above Kellogg Branch)
	Deer Creek					23.8/Mouth of Kellogg Branch
		Kellogg Branch				2.3/Head of Kellogg Branch
		Kellogg Branch				1.5/Bridge, Knopp Road
		Kellogg Branch				1.4/Bridge, Knopp Road
		Kellogg Branch				___/Outfall, Henry Rigdon Cannery
		Kellogg Branch				1.3/Bridge, Rush Road
		Kellogg Branch				1.0/Camp Wo-Me-To
		Kellogg Branch				0.4/Bridge, Rigdon Road
		Kellogg Branch				0.1/Bridge, Md. Highway #24
		Kellogg Branch				0.0/Mouth of Kellogg Branch
	Deer Creek					23.8/Mouth of Kellogg Branch
	Deer Creek					23.7/Bridge, Md. & Pa. R.R.
	Deer Creek					23.5/Gaging Station, at Rocks, Md. (D.A. 94.4)
	Deer Creek					23.1/Bridge, Cherry Hill Rd.
	Deer Creek					22.3/Mouth of South Stirrup Run
		South Stirrup Run				3.1/Head of South Stirrup Run
		South Stirrup Run				2.2/Bridge, Bailey Road
		South Stirrup Run				1.6/Bridge, Md. & Pa. R.R.
		South Stirrup Run				1.4/Bridge, Sharon Road
		South Stirrup Run				0.4/Mouth of North Stirrup Run

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway)						LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway)					
1	2	3	4	5	6	1	2	3	4	5	6
			North Stirrup Run						2.7/Head of North Stirrup Run		
			North Stirrup Run						1.9/Bridge, Rigdon Road		
			North Stirrup Run						1.4/Bridge, Rigdon Road		
			North Stirrup Run						0.8/Bridge, Sharon Road		
			North Stirrup Run						0.1/Bridge, Md. & Pa. R.R.		
			North Stirrup Run						0.0/Mouth of North Stirrup Run		
		South Stirrup Run						0.4/Mouth of North Stirrup Run			
		South Stirrup Run						0.2/Bridge, Md. Highway #24 (Rocks Rd.)			
		South Stirrup Run						0.0/Mouth of South Stirrup Run			
	Deer Creek						22.3/Mouth of South Stirrup Run				
	Deer Creek						20.4/Bridge, Grier Nursury Rd.				
	Deer Creek						17.4/Mouth of Stout Bottle Branch				
		Stout Bottle Branch						3.7/Head of Stout Bottle Branch			
		Stout Bottle Branch						3.3/Bridge, Johnson Mill Rd.			
		Stout Bottle Branch						1.8/Bridge, Chestnut Hill Road			
		Stout Bottle Branch						1.5/Mouth of Cabbage Run			
			Cabbage Run						2.6/Head of Cabbage Run		
			Cabbage Run						1.8/Bridge, Johnson Mill Rd.		
			Cabbage Run						0.1/Bridge, Chestnut Hill Rd.		
			Cabbage Run						0.0/Mouth of Cabbage Run		
		Stout Bottle Branch						1.5/Mouth of Cabbage Run			
		Stout Bottle Branch						0.6/Bridge, Deer Creek Church Rd.			
		Stout Bottle Branch						0.1/Bridge, Walters Mill Rd.			
		Stout Bottle Branch						0.0/Mouth of Stout Bottle Branch			
	Deer Creek						17.4/Mouth of Stout Bottle Branch				
	Deer Creek						17.2/Bridge, Md. Highway #543				
	Deer Creek						16.5/Mouth of St. Omer Branch				
		St. Omer Branch						3.0/Head of St. Omer Branch			
		St. Omer Branch						1.6/Bridge, Gibson Road			
		St. Omer Branch						0.1/Bridge, Walters Mill Rd.			
		St. Omer Branch						0.0/Mouth of St. Omer Branch			
	Deer Creek						16.5/Mouth of St. Omer Branch				
	Deer Creek						14.3/Bridge, Sandy Hook Rd.				
	Deer Creek						12.4/Bridge, U. S. Highway #1				
	Deer Creek						11.4/Bridge, Forge Hill Rd.				
	Deer Creek						10.2/Mouth of Thomas Run				
		Thomas Run						5.0/Head of Thomas Run			
		Thomas Run						4.0/Bridge, Ruffs Mill Rd.			
		Thomas Run						3.5/Bridge Thomas Run Rd.			
		Thomas Run						2.8/Bridge, Pennington Rd.			
		Thomas Run						1.4/Bridge, Thomas Run Rd.			
		Thomas Run						0.0/Mouth of Thomas Run			
	Deer Creek						10.2/Mouth of Thomas Run				
	Deer Creek						9.7/Mouth of Tobacco Run				
		Tobacco Run						3.2/Head of Tobacco Run			
		Tobacco Run						2.8/Bridge Medical Hall Rd.			
		Tobacco Run						0.7/Bridge, Cool Spring Rd.			
		Tobacco Run						0.0/Mouth of Tobacco Run			
	Deer Creek						9.7/Mouth of Tobacco Run				
	Deer Creek						9.0/Bridge, Md. Highway #136				

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
Deer Creek	9.0/Gaging Station near Churchville, Md. (D.A. 141)
Deer Creek	8.1/Mouth of Cool Branch Run
Cool Branch Run	3.5/Head of Cool Branch Run
Cool Branch Run	0.2/Bridge, Harmony Church Rd.
Cool Branch Run	0.0/Mouth of Cool Branch Run
Deer Creek	8.1/Mouth Cool Branch Run
Deer Creek	7.6/Mouth of Mill Brook
Mill Brook	4.5/Head of Mill Brook
Mill Brook	3.6/Bridge, Md. Highway #155
Mill Brook	2.0/Bridge, Old Level Rd.
Mill Brook	0.4/Bridge, Harmony Church Rd.
Mill Brook	0.0/Mouth of Mill Brook
Deer Creek	7.6/Mouth of Mill Brook
Deer Creek	7.0/Nobles Mill & Dam
Deer Creek	6.9/Bridge, Nobles Mill Rd.
Deer Creek	6.5/Mouth of Hopkins Branch
Hopkins Branch	2.6/Head of Hopkins Branch
Hopkins Branch	1.4/Bridge, Trappe Church Rd.
Hopkins Branch	0.0/Mouth of Hopkins Branch
Deer Creek	6.5/Mouth of Hopkins Branch
Deer Creek	5.5/Mouth of Hollands Branch
Hollands Branch	2.2/Head of Hollands Branch
Hollands Branch	0.8/Bridge, Trappe Church Rd.
Hollands Branch	0.0/Mouth of Hollands Branch
Deer Creek	5.5/Mouth of Hollands Branch
Deer Creek	5.1/Mouth of Graveyard Creek
Graveyard Creek	3.4/Head of Graveyard Creek
Graveyard Creek	2.6/Bridge, Old Level Rd.
Graveyard Creek	1.0/Bridge, Glenville Rd.
Graveyard Creek	0.0/Mouth of Graveyard Creek
Deer Creek	5.1/Mouth of Graveyard Creek
Deer Creek	4.6/Dam
Deer Creek	4.2/Wilson Mill
Deer Creek	4.2/Bridge, Md. Highway #161, (Darlington Rd.)
Deer Creek	4.0/Outfall, Jordon & Sons, Darlington, Md.
Deer Creek	3.6/Intake, Aberdeen Proving Grounds
Deer Creek	1.9/Mouth of Elbow Branch
Elbow Branch	2.9/Head of Elbow Branch
Elbow Branch	2.6/Bridge, Md. Highway #161
Elbow Branch	1.3/Bridge, Wilkinson Rd.
Elbow Branch	0.0/Mouth of Elbow Branch
Deer Creek	1.9/Mouth of Elbow Branch
Deer Creek	1.5/Bridge, Stafford Bridge
Deer Creek	1.5/Mouth of Buck Branch
Buck Branch	1.6/Head of Buck Branch
Buck Branch	0.0/Mouth of Buck Branch
Deer Creek	1.5/Mouth of Buck Branch
Deer Creek	0.1/Bridge, Power Company R.R.
Deer Creek	0.0/Mouth of Deer Creek (D.A. 170.7)

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER	7.6/Mouth of Deer Creek
SUSQUEHANNA RIVER	7.5/Upstream end of Robert Island
SUSQUEHANNA RIVER	7.2/Mouth of Rock Run
Rock Run	3.6/Head of Rock Run near Level, Maryland
Rock Run	1.9/Bridge, Cooley Mill Rd.
Rock Run	0.4/Bridge, Rock Run Rd.
Rock Run	0.2/Bridge, Stafford Rd.
Rock Run	0.1/Bridge, Power Company R.R.
Rock Run	0.0/Mouth of Rock Run
SUSQUEHANNA RIVER	7.2/Mouth of Rock Run
SUSQUEHANNA RIVER	6.8/Downstream end of Robert Island
SUSQUEHANNA RIVER	6.7/Intake, Bainbridge U.S.N. Training Center
SUSQUEHANNA RIVER	6.7/Mouth of Rock Run
Rock Run	3.0/Head of Rock Run, near Woodlawn, Md.
Rock Run	1.6/Bridge, Rowland Rd.
Rock Run	1.3/Bridge, Rowland Rd.
Rock Run	0.6/Bridge, Md. Highway #269
Rock Run	0.2/Bridge, U.S. Highway #222
Rock Run	0.1/Pa. R.R. Bridge
Rock Run	0.0/Mouth of Rock Run
SUSQUEHANNA RIVER	6.7/Mouth of Rock Run
SUSQUEHANNA RIVER	6.7/Upstream end of Spencer Island
SUSQUEHANNA RIVER	6.3/Downstream end of Spencer Island
SUSQUEHANNA RIVER	5.2/Bainbridge Naval Training Center
SUSQUEHANNA RIVER	5.0/Mouth of Herring Run
Herring Run	2.9/Head of Harring Run near Earlton, Md.
Herring Run	0.1/Bridge, Power Company, R.R.
Herring Run	0.0/Mouth of Herring Run
SUSQUEHANNA RIVER	5.0/Mouth of Herring Run
SUSQUEHANNA RIVER	5.0/Outfall, Port Deposit
SUSQUEHANNA RIVER	4.8/Mouth of Happy Valley Branch
Happy Valley Branch	2.2/Head of Happy Valley Branch in Bainbridge Naval Training Center, Cecil Co., Md.
Happy Valley Branch	1.1/Outfall, Bainbridge, U.S.N. Training Center
Happy Valley Branch	1.0/Bridge, U.S. Highway #222
Happy Valley Branch	0.8/Bridge, Frenchtown Rd.
Happy Valley Branch	0.1/Bridge, Pa. R.R.
Happy Valley Branch	0.0/Mouth of Happy Valley Branch
SUSQUEHANNA RIVER	4.8/Mouth of Happy Valley Branch
SUSQUEHANNA RIVER	1.9/Bridge, B&O R.R.
SUSQUEHANNA RIVER	1.5/Bridge, U.S. Highway #40
SUSQUEHANNA RIVER	1.2/Town of Perryville
SUSQUEHANNA RIVER	1.1/Outfall, Perryville, Md.
SUSQUEHANNA RIVER	1.0/Bridge, Pa. R.R.
SUSQUEHANNA RIVER	1.0/Outfall, A.H. Owens & Son, Marina
SUSQUEHANNA RIVER	___/Intake Havre de Grace, Md.
SUSQUEHANNA RIVER	0.8/Outfall at Havre de Grace
SUSQUEHANNA RIVER	0.5/Outfall, E.V. Stockham, Inc.

SUSQUEHANNA RIVER DRAINAGE BASIN

DISTANCES FROM MOUTH OF WATERWAY AND DRAINAGE AREAS FOR SPECIFIC LOCATIONS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 2 3 4 5 6
SUSQUEHANNA RIVER	___/Intake, Veterans Administration Hospital
SUSQUEHANNA RIVER	0.4/Outfall at Veterans Administration Hospital
SUSQUEHANNA RIVER	0.0/Mouth of Susquehanna River (D.A. 27,469)

D.A. - Drainage Area, square miles

*Susquehanna River discharges into the head of Chesapeake Bay at point 193 statute miles above the mouth of the bay.

**From mile point 47.7 to mile point 16.3, the Susquehanna River is boundary between York and Lancaster Counties, Pa.

***From mile point 15.1 to the mouth, the Susquehanna River is boundary between Cecil and Harford Counties, Md.

January, 1965

APPENDIX B

WATER-QUALITY STATIONS, WATER WITHDRAWN, WASTES DISCHARGED AND STREAMFLOWS

See Description of Appendices (Appendix B) in the General Reference Section for a narrative discussion of this material.

Appendix B

SUSQUEHANNA RIVER DRAINAGE BASIN

WATER-QUALITY STATIONS, WATER WITHDRAWN, WASTES DISCHARGED, AND STREAM FLOWS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 - 2 - 3 - 4 - 5 - 6	Water intake, mgd	Waste discharge mgd	Daily Stream Flow, cfs	
				Minimum	Lower 5 Percentile
SUSQUEHANNA RIVER	___/Gaging Station, McCalls Ferry, Pa.			X	X
SUSQUEHANNA RIVER	45.9/Gaging Station at Marietta, Pa.			2700.0	X
Conestoga Creek	33.3-___/Gaging Station at Lancaster, Pa.			69.0	X
Muddy Creek					
Scott Creek	22.6- 6.9-3.3/Outfall, Md. Green Marble Co.		X		
Scott Creek	22.6- 6.9-3.3/Outfall, Whiteford Packing Co.		X		
Muddy Creek	22.6- 3.4/Gaging Station at Castle Fin, Pa.			X	X
SUSQUEHANNA RIVER	19.9/Intake, Peach Bottom Atomic Power Station, Philadelphia Electric Co.	X			
Broad Creek	15.1-13.1/Gaging Station at Pylesville, Md.			X	X
Broad Creek	15.1-9.0/Outfall, Western Md. Dairy, Pylesville, Md.		.030		
Broad Creek	15.1- 8.7/Gaging Station, Mill Green, Md.			8.0	X
Deep Creek	15.1- 3.2-1.0/Intake, Broad Creek Memorial Scout Camp	X			
Conowingo Creek	12.9- 2.4/Intake, Girl Scout Camp, East of Pilot, Md.	X			
SUSQUEHANNA RIVER	10.9/Intake, Conowingo, Md.	0.011			
SUSQUEHANNA RIVER	10.9/Conowingo Dam (future Balto. City Intake)	300.000			
SUSQUEHANNA RIVER	10.9/Outfall, Conowingo, Md.		.018		
Octoraro Creek	10.2-___/Intake, Chester, Pa.	X			
Stone Creek	10.2- 6.5- 2.0/Outfall, Western Md. Dairy		X		

SUSQUEHANNA RIVER DRAINAGE BASIN

WATER-QUALITY STATIONS, WATER WITHDRAWN, WASTES DISCHARGED, AND STREAM FLOWS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 - 2 - 3 - 4 - 5 - 6	Water intake, mgd	Waste discharge mgd	Daily Stream Flow, cfs	
				Minimum	Lower Percentile
Stone Creek	10.2- 6.5- 2.0/Outfall, Rising Sun, Md.		.013		
Octoraro Creek	10.2- 3.5/Gaging Station, Rising Sun, Md.			22.0	74.0
Basin Run	10.2- 1.0- 3.0/Outfall, J. Wm. Liddell		.020		
Basin Run	10.2- 1.0- 3.0/Outfall, Silver Canning Co		.020		
Basin Run	10.2- 1.0- 3.0/Gaging Station, Liberty Grove, Md.			0.5	1.6
Octoraro Creek	10.2- 1.0/Gaging Station, Rowlandsville, Md.			X	X
Deer Creek Harris Mill Creek Little Deer Creek Unnamed Ditch	7.6-43.3- 1.5-____-0.25/Outfall, Krout and Shaffer		X		
Deer Creek	7.6-24.0/Gaging Station at Rocks, Md. (above Kellogg Branch)			X	X
Kellogg Branch	7.6-23.8-____/Outfall, Henry Rigdon Cannery		.010		
Deer Creek	7.6-23.5/Gaging Station at Rocks, Md.			13.0	43.0
Deer Creek	7.6- 9.0/Gaging Station nr. Churchville, Md.			80.0	X
Deer Creek	7.6- 4.0/Outfall, Jordon & Sons, Darlington, Md.		.030		
Deer Creek	7.6- 3.6/Intake, Aberdeen Proving Grounds	2.400			
SUSQUEHANNA RIVER	6.7/Intake, Bainbridge U.S.N. Training Center	1.200			
SUSQUEHANNA RIVER	5.0/Outfall, Port Deposit		.066		

WATER-QUALITY STATIONS, WATER WITHDRAWN, WASTES DISCHARGED, AND STREAM FLOWS

MAIN WATERWAYS AND TRIBUTARIES (Magnitude of Waterway) 1 2 3 4 5 6	LOCATION: RIVER MILE/DESCRIPTION (Magnitude of Waterway) 1 - 2 - 3 - 4 - 5 - 6	Water intake, mgd	Waste discharge mgd	Daily Stream Flow, cfs	
				Minimum	Lower 5 Percentile
Happy Valley Branch	4.8- 1.1/Outfall, Bainbridge U.S.N. Training Center		.600		
SUSQUEHANNA RIVER	1.1/Outfall, Perryville, Md.		.055		
SUSQUEHANNA RIVER	1.0/Outfall, A. H. Owens and Son		X		
SUSQUEHANNA RIVER	___/Intake, Havre de Grace	1.000			
SUSQUEHANNA RIVER	0.8/Outfall, Havre de Grace		.800		
SUSQUEHANNA RIVER	0.5/Outfall, E. V. Stockham, Inc.		.060		
SUSQUEHANNA RIVER	___/Intake, Veterans Administration Hospital, Perry Point	.500			
SUSQUEHANNA RIVER	0.4/Outfall, Veterans Administration Hospital, Perry Point		.270*		

* Discharge to Susquehanna or Mill Creek

X Data not available.

October, 1964

APPENDIX C

RESERVOIRS, LAKES AND PONDS

See Description of Appendices (Appendix C) in the General Reference Section for a narrative discussion of this material.

APPENDIX C

RESERVOIRS, LAKES AND PONDS IN SUSQUEHANNA RIVER DRAINAGE BASIN, MARYLAND*

Stream	Reservoir, Lake or Pond	Water Surface Area, Acres	Location of Dam	
			County	Maryland Coordinates
Susquehanna River	Conowingo Reservoir	5,000.0	Harford	1034-667
Broad Creek	Broad Creek Lake	54.0	Harford	0970-680
Octoraro Creek	Rising Sun Pond	1.0	Cecil	1064-680
Deer Creek				
Little Deer Creek				
Cattail Branch	Cattail Retention Reservoir	7.0	Harford	0937-639
Rock Run	Webster Village Pond	3.0	Harford	1036-634

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* Source: 1961 Maryland Impoundments Inventory, Department of Game and Inland Fish. Impoundments included in the inventory are used for recreation.

APPENDIX D

STORAGE REQUIREMENTS FOR SUSTAINED YIELDS

See Description of Appendices (Appendix D) in the General Reference Section for a narrative discussion of this material.

APPENDIX D

Storage Requirements for Sustained Yields

The following table lists the artificial storage requirements, computed as outlined in the Description of Appendices, General Reference Section, for streams in the Maryland section of the Susquehanna River Basin.

The storage values are given in terms of mean annual flow, but can be converted easily into volumes by use of the relation:

$$\frac{V_s}{M} = R_s$$

in which

V_s = volume of storage required;

M = mean annual flow in acre-feet; and

R_s = storage ratio (from table)

For example the following table gives a storage ratio of 0.592 for a gross yield of 0.9M on Octoraro Creek near Rising Sun, Maryland. Mean flow = 256 cfs (from column 3)

$$M = 256 \text{ ft.}^3 \times \text{sec.}^{-1} \times \underline{1.98 \text{ acre-feet} \times \text{day}^{-1}} \times 365 \text{ days}$$

$$M = 256 \times 1.98 \times 365 \text{ acre-feet}$$

$$V_s = R_s M = 0.592 \times 256 \times 1.98 \times 365$$

$$V_s = 109{,}200 \text{ acre-feet}$$

This means that a reservoir holding 109,200 acre-feet of water on Octoraro Creek above the stream gage near Rising Sun will provide a gross yield of 230 cfs (equal to 256 cfs times 0.9) for 19 out of every 20 years, on the average. Except for seepage, evaporation losses, and diversions, the 230 cfs would be sustained at the gage.

APPENDIX D
Table D-1

Storage Requirements for Various Gross Yields[a]

SUSQUEHANNA RIVER BASIN

(Recurrence Interval = 20 Years)

Stream and Gaging Station (1)	Drainage area, sq. miles (2)	Mean annual flow, cfs (3)	Coeff. of Variation (4)	Natural Storage Constant, days (5)	Storage in terms of mean annual flow for various yields			
					Yield in Terms of Mean Annual Flow			
					0.3 (6)	0.5 (7)	0.7 (8)	0.9 (9)
Susquehanna River at Marietta, Pa.	25,990[b]	36,586	0.19	--	--	--	--	--
Conestoga Creek at Lancaster, Pa.	324	386	0.28	--	--	--	--	--
Octoraro Creek near Rising Sun, Md.	193	253	0.18	76[c]	0.033[c]	0.126[c]	0.233[c]	0.592[c]
Basin Run at Liberty Grove, Md.	5.31	6.74	0.31	89	0.026	0.123	0.353	1.150[d]
Deer Creek at Rocks, Md.	94.4	123	0.26	121	0.004	0.065	0.207	0.792

Footnotes

[a] Gross yield includes evaporation losses and seepage losses.

[b] Drainage area includes that of Chickies Creek which joins the Susquehanna River just below the gage at Marietta.

[c] Based on conditions before diversion from Pine Grove Reservoir beginning 1951 by Chester Municipal Authority for publi water supply of Chester, Pa., and surrounding boroughs.

[d] Storage capacity greater than unity cannot be filled every year except by importation of water to the reservoir from another watershed.

APPENDIX E

SURFACE WATER PERMITS

See Description of Appendices (Appendix E) in the General Reference Section for a narrative discussion of this material.

APPENDIX E

SUSQUEHANNA RIVER DRAINAGE BASIN
SURFACE-WATER APPROPRIATION PERMITS[a]

Firm Name and Address (1)	County (2)	Classi-fication Number (3)	Stream (4)	Sub-Basin (5)	Appropri Amount, (6)
Girls Scout Council, Baltimore Area, near Pilot	Cecil	--	Conowingo Creek	Conowingo Creek	

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[a] Information in columns 1,4, and 6 supplied by Department of Geology, Mines, and Water Resources, State of Maryland Baltimore, Maryland

Revised 2 October 1963

APPENDIX F

GROUND WATER PERMITS

See Description of Appendices (Appendix F) in the General Reference Section for a narrative discussion of this material.

MARYLAND WATER RESOURCES INVENTORY

GROUND-WATER APPROPRIATION PERMITS*

BY COUNTY, PARTLY OR WHOLLY WITHIN THE SUSQUEHANNA RIVER DRAINAGE BASIN

Permit Holder Name and Address (1)	Standard Industrial Classification Number (2)	Number of Employees (3)	Appropriation Permitted (m.g.d.) (4)	Actual Withdrawal (m.g.d.) (5)
CECIL COUNTY				
Mason and Dixon Sand and Gravel, Perryville	1441	(N)	0.048	--
Meadowview Utilities, Meadowview	(U)	(N)	0.350	--
Morning Cheer, Inc., Rowlandsville	(U)	(N)	0.040	--
Wiley Mfg. Co., Port Deposit	3731 3441	308	0.016	--
Harford County				
Bramblewood Children's Camp, Darlington	7032	(N)	0.010	--
Broad Creek Memorial Camp	7032	(N)	0.030	--
Camp Ramblewood, Darlington	7032	(N)	0.050 0.040	--
Coca-Cola Bottling Works, Inc., Havre de Grace	2086	41	0.025	--
Albert and Jewell Di Domenico Havre de Grace	5812	(N)	0.072	--

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* Data furnished by the Maryland State Department of Geology, Mines, and Water Resources, May, 1963.

(E) Classification number has been estimated.

(N) Number of employees not listed in Directory of Maryland Manufactures, 1963 edition.

(U) Product or products unknown.

(Revised October 2, 1963)

GROUND-WATER APPROPRIATION PERMITS

Permit Holder Name and Address (1)	Standard Industrial Classification Number (2)	Number of Employees (3)	Appropriation Permitted (m.g.d.) (4)	Actual Withdrawal (m.g.d.) (5)
HARFORD COUNTY				
Harford County Distillery, Inc., Havre de Grace	2085	(N)	0.700	--
Lock Joint Pipe Co., Perryman	3272	281	0.120	--
J. Grafton Osborn Aberdeen	2033	(N)	0.030 0.060	--
Henry Rigdon, Rocks	(U)	(N)	0.050	0.003
H. P. White Scarboro	(U)	(N)	0.050	--
Whiteford Packing Co. Whiteford	2037	18	0.0288	--

Compiled July, 1963 by J.C. Meredith, U.S. Public Health Service; and E.S. Mills, The Johns Hopkins University. Data in columns 1, 2 and 5 obtained from the files of the Maryland Department of Geology, Mines, and Water Resources.

(Revised October 2, 1963)

APPENDIX G

INDUSTRIAL WATER USERS SUPPLIED BY PUBLIC WATER SYSTEM, CITY OF BALTIMORE, MARYLAND

(OMITTED IN THIS REPORT - APPLICABLE ONLY TO CHESAPEAKE BAY WEST REPORT)

APPENDIX H

ABSTRACTS OF PUBLISHED REPORTS ON GROUND-WATER RESOURCES

See Description of Appendices (Appendix H) in the General Reference Section for a narrative discussion of this material.

APPENDIX H

GROUND WATER IN MARYLAND

PIEDMONT

by

C. L. McGuinness

The Piedmont is underlain by crystalline and sedimentary rocks which are generally reliable sources of the small supplies, 5 to 10 gpm, needed for domestic and stock supply. A few wells yield as much as 200 gpm. Limestone and marble, and sandstone and shale of the Triassic belt, are the sources of many of the larger supplies. Rather commonly, the yields of the more productive wells tend to decrease if the pumping is heavy and continuous.

In a few localities, even domestic supplies are hard to get; well yields are low and water levels decline under prolonged pumping. Information is needed on the principles of occurrence of water in the crystalline rocks to explain these poorly productive localities and to enable predicting the best well sites in them.

The ground water is generally of good quality except that some of it is slightly corrosive, high in iron, or, locally in areas of limestone or marble, excessively hard.

The total pumpage of ground water in the area, which covers about three-tenths of the State, was about 18 mgd in 1960. This is only a small fraction of the total that could be pumped from wells distributed over the whole area.

Source: McGuinness, C. L. 1963. The Role of Ground Water in the National Situation. Geological Survey Water-Supply Paper 1800, pp. 398-399.

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APPENDIX H

GROUND WATER IN MARYLAND

COASTAL PLAIN, WESTERN SHORE*

by

C. L. McGuinness

On the Western Shore the yields of wells developed and equipped for maximum capacity range from a few hundred gallons per minute to as much as 1,200 gpm in the most favorable areas. Along the Fall Line the yields are small because the sediments are thin and also are dissected and tend to drain out rapidly. In the southwestern part of the Maryland Coastal Plain, from Washington, D. C., down to Indian Head, the water-bearing sands are generally thin and fine grained and well yields tend to be small. Water levels are declining in localities where pumping is heavy.

The northern part of the Western Shore is more productive, at least where developed to date. Pumping is concentrated largely in the Baltimore industrial area and in the northern half of Anne Arundel County, and there is substantial pumping at military installations scattered over the whole Western Shore.

The total pumpage on the Western Shore in 1960 was about 54 mgd, about half of which was pumped at Baltimore. The total is likely to increase substantially in the future, and the available reports will help to promote the additional development by showing the areas within each county where the prospects are best.

The water from the oldest sediments, the Cretaceous, commonly is slightly acid, corrosive, and high in iron content. As much as 50 ppm

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* As used by McGuinness, the Western Shore area includes the Coastal Plain portions of Harford, Baltimore, Anne Arundel, Calvert, Prince George's, Charles, and St. Mary's Counties, and of Baltimore City.

of iron has been measured in wells near Washington, D. C., a highly excessive value when the Public Health Service's recommended limit of 0.3 ppm for iron and manganese together is considered. The average iron content is much less, but it commonly exceeds 0.3 ppm.

Baltimore obtains its public water supply from two impounding reservoirs on the stream known as Gunpowder Falls and one on the Patapsco River. The average daily intake of raw water in 1960 was 211 mgd. About 24 mgd of ground water is pumped, nearly all from industrial and commercial wells. About 70 mgd of treated sewage is used by industry, most of it at a steel mill at Sparrows Point.

Saline water has encroached from the Patapsco River Estuary into the shallower Cretaceous aquifers along the shore in a large part of the Baltimore area. The ground water is contaminated also by industrial wastes which enter the aquifers through the corroded, leaky casings of wells. The pumping in the industrial area, formerly heavier, has become more or less stabilized at the present rate as a consequence of the contamination that has already occurred and of its tendency to spread at higher rates of pumping.

The public water supply is to be supplemented about 1963 by water brought in a conduit from the Susquehanna River. The new supply will add about 500 mgd to the reliable yield, now estimated at 243 mgd.

A comprehensive quantitative report on ground water in the Baltimore area is available (Bennett and Meyer, 1952), but the work needs to be updated by means of an inventory of pumpage and quality-of-water data.

Source: McGuinness, C. L. 1963. The Role of Ground Water in the National Situation, Geological Survey Water-Supply Paper 1800, pp. 399-400).

APPENDIX H

GEOLOGY AND GROUND-WATER RESOURCES OF THE BALTIMORE AREA

by

Robert R. Bennett and Rex R. Meyer

- Abstract -

The Baltimore area comprises the city of Baltimore, and most of the area from the Susquehanna River south to Laurel, essentially between the Piedmont Plateau and the Chesapeake Bay. Most of the large ground-water developments are in the industrial districts in and near Baltimore; consequently that part of the area was investigated in greater detail. With the exception of the northern part of Baltimore, which is in the Piedmont Plateau, the area is chiefly in the Coastal plain.

The Piedmont Plateau is underlain by pre-Cambrian crystalline rocks consisting mostly of gabbro, schist, granite, and gneiss. Owing to their greater resistance to erosion the land surface of the plateau is higher and more rugged than the Coastal Plain, which is underlain by soft unconsolidated sediments of Lower and Upper Cretaceous and Pleistocene ages. The land surface of the Coastal Plain slopes gently southeastward toward Chesapeake Bay. In some places estuaries, which are tributaries of Chesapeake Bay, extend northwestward across the Coastal Plain to the Piedmont Plateau.

The Coastal Plain sediments were deposited on the southeastward-sloping surface of the crystalline rocks. They form a wedge-shaped mass that thickens progressively from west to east. The strike of the formations of Cretaceous age is approximately parallel to the boundary between

the Piedmont Plateau and the Coastal Plain (Fall Line). As these formations dip gently to the southeast they crop out as bands of irregular width trending northeast. The Pleistocene deposits are essentially flat lying and were deposited on the eroded surface of the pre-Cambrian and Cretaceous rocks.

In most of the area the sediments of Lower and Upper Cretaceous age, which consist essentially of irregular and lenticular beds of sand, gravel, and clay of continental origin, may be divided into three formations: The Patuxent formation of Lower Cretaceous age, and the Arundel clay and Patapsco formation of Upper Cretaceous age. Their combined thickness ranges from about 475 to 750 feet. The Pleistocene deposits, which consist chiefly of irregular beds of sand, gravel, and clay of continental and esturine origin, are divided, in this report, into an upland and lowland unit. The combined thickness of these units ranges from nearly nothing to 175 feet.

Owing to the great difference in water-bearing properties of the crystalline rocks in the Piedmont Plateau and the unconsolidated sediments in the Coastal Plain, ground water occurs under two widely different sets of conditions. In the crystalline rocks the water is contained chiefly in joints and other fractures which are not uniform in size and gradually disappear with depth, consequently the water-bearing zones are very irregular and inhomogeneous. The sand and gravel in the Coastal Plain sediments are considerably more porous and permeable and form relatively uniform and widespread aquifers. In general water-table conditions occur in the outcrop areas of the crystalline rocks and the Coastal Plain sediments, but down dip from the outcrops the ground water occurs under artesian conditions. Because of their low permeability, where they underlie a substantial thickness of unconsolidated sediments

the crystalline rocks are not considered to be an aquifer in most of the Coastal Plain area.

The reported yields from 106 industrial wells ending in the crystalline rocks in Baltimore show an average yield of 50 gallons a minute, and a median yield of 35; the mode, or most typical value, is 10 gallons a minute. The reported yields range from 0 to 350 gallons a minute.

Industrial wells in the Patuxent formation in and near its outcrop have yields of about 200 to 300 gallons a minute, whereas wells in this formation down dip in the southeastern part of the area have yields of about 500 to 900 gallons a minute. Pumping tests and flow net analysis show that the coefficient of transmissibility of the Patuxent formation, the principal water-bearing formation in the area, averages about 20,000 gallons a day per foot in the industrial districts near the outcrop, and about 50,000 in the industrial districts in the southeastern part of the area. The coefficient of storage of the Patuxent formation, under artesian conditions, is about 0.00026; under water-table conditions in the outcrop area, it is estimated to be 0.15 to 0.20.

The Patapsco formation is an important water-bearing formation in the southeastern part of the industrial area where it is separated by clay into a lower and upper aquifer. The lower aquifer yields as much as 500 to 750 gallons a minute to industrial wells. Its coefficient of transmissibility averages about 25,000 gallons a day per foot. The upper aquifer, which yields as much as 500 to 800 gallons a minute to wells, has a greater thickness than the lower aquifer, so that its coefficient of transmissibility probably is more than 25,000.

The upland unit of the Pleistocene deposits is thin and caps the

hills and ridges and is not an important aquifer. In some places, the lowland unit is sufficiently thick and permeable to yield large quantities of water to wells.

The large ground-water supplies in the industrial area have been developed since about 1900. The pumpage increased progressively to a peak of about 47,000,000 gallons a day early in 1942. Late in 1942 the pumpage was decreased by about 13,000,000 gallons a day and in 1945 was 34,000,000 gallons a day. From 1942 to 1945 the pumpage outside the industrial area increased from about 3,000,000 to 5,000,000 gallons a day. The total pumpage in 1945 for the entire area was 39,000,000 gallons a day. The pumpage, in gallons a day, from each water-bearing formation, is approximately: pre-Cambrian crystalline rocks, 1,000,000; Patuxent formation, 30,000,000; Patapsco formation, 6,000,000; and Pleistocene deposits, 3,000,000.

Originally the artesian head in the aquifers generally was within a few feet of the land surface, but with the progressive increase in pumpage during 1940 to 1942 the artesian head in the Patuxent and Patapsco formations, in and near the centers of pumpage, declined respectively to as much as 160 and 190 feet below the land surface. The decrease in pumpage late in 1942 resulted in a rise in the artesian head; and at present, in most of the industrial area, the artesian head in the Patuxent and Patapsco formations ranges, respectively, from about 40 to 100 and 10 to 50 feet below the land surface. Detailed records of water-level fluctuations in observation wells show that during 1943-1945 the general trend of water levels in most parts of the area was either slightly upward or essentially horizontal.

The ground water in the Baltimore area normally has a low mineral

content, but the lowering of the water table or artesian head has caused salt water, chiefly from the Patapsco River estuary, to enter the aquifers and spread laterally throughout a large part of the industrial area.

Industrial wastes, chiefly sulfuric acid, also have contaminated the ground water in a small part of the industrial area.

The contamination of aquifers through leaking wells is a serious ground-water problem in the industrial area. As the artesian head in the Patuxent formation is lower than it is in the Patapsco formation or Pleistocene deposits, highly mineralized water may enter a well through a defective casing or move downward outside an improperly sealed casing and contaminate the water in the Patuxent formation. Although this problem is now serious, the repair of leaking active wells and effective plugging of abandoned wells would appreciably reduce this contamination in a relatively short time.

Practically all ground water pumped in the Baltimore area is derived from precipitation on the outcrops of the aquifers. The potential rate of recharge to the aquifers in the Coastal Plain exceeds the theoretical maximum quantity of water that can be transmitted through them. The rate of recharge, therefore, does not limit the quantity of water that can be pumped in the artesian part of the area.

The concentration of pumping has caused the water table or artesian head in the Patuxent formation to be so low in and near some of the centers of pumping that very little additional water can be developed from that formation in those parts of the industrial area. The water table or artesian head between the centers of pumping, however, is relatively high and if the wells were spaced at greater distances additional water could be pumped. The heavy pumping from the Patuxent

formation, chiefly in and near its outcrop adjacent to the Patapsco River estuary, has caused local encroachment of salt water. However, as pumping in and near that part of the outcrop area prevents most of the salt water now in the formation from moving to major well fields in the other industrial districts, it would not be advisable to decrease or discontinue this pumping.

Heavy pumping over a period of many years throughout the industrial area has caused local encroachment of salt water in the Patapsco formation, so that most of the pumping from the formation has been discontinued. The present pumpage is chiefly from the aquifer in the lower part of the formation in the southeastern part of the area where a large part of the water is derived from areas in which the Patapsco formation contains fresh water. Although this pumping is still causing encroachment of salt water, it would not be desirable to discontinue the pumping at least until all leaking wells drilled to the Patuxent formation are repaired or plugged. Even if the pumping were discontinued, many decades would pass before the salt water in the formation would be flushed out. It would not be advisable, however, to develop additional supplies of ground water from this formation in the industrial districts up dip as they are near the main source of contamination.

The economic value of ground water in the industrial area is different for various types of uses and there is little uniformity in the chemical quality of water that can be used. The application of the term safe yield in the sense that it represents a single rate of pumping for the entire industrial area would be unrealistic. It is apparent that owing to the contamination of the water the safe yield has been exceeded for some industries.

Source: Bennett R. R. and Meyer R. R. 1952. Geology and Ground-Water Resources of the Baltimore Area: Maryland Department Geology, Mines and Water Resources. Bulletin 4.

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APPENDIX H

THE WATER RESOURCES OF BALTIMORE AND HARFORD COUNTIES

The Ground-Water Resources of the Piedmont Part

by

R. J. Dingman and H. F. Ferguson

- Abstract -

Baltimore and Harford Counties lie in two physiographic provinces, the Coastal Plain to the southeast and the Piedmont to the northwest. This report deals with the Piedmont province, where the rocks are largely hard Precambrian or lower Paleozioc schist, quartzite, granite, gabbro, marble, and phyllite. Ground water in the crystalline rocks generally occurs under water-table conditions, although artesian conditions exist locally. The source of all ground water in the area is precipitation. The precipitation averages about 43 inches per year and is generally rather evenly distributed throughout the year.

More than 70 per cent of the drilled wells have yields of 10 gallons per minute or less, and only 2 per cent have yields in excess of 50 gallons per minute. The Baltimore Gneiss is an important aquifer in which the yields of 116 wells range from 0 to 110 gallons per minute and average a little better than 10 gallons per minute. A value for the coefficient of transmissibility obtained from a pumping test of a well in the gneiss was about 5,000 gallons per day per foot. The Wissahickon formation is divided into two rock types, an oligoclase-mica facies and an albite-chlorite facies. The yields of more than 230 wells in the oligoclase-mica facies average better than 11 gallons per minute. Generally, the best wells are in areas where the rocks are deeply weathered. The average yield

of 76 wells ending in the albite-chlorite facies is 10 gallons per minute. The average depth of the wells in the Wissahickon is 92 feet. The Cockeysville marble is the best squifer in the area. The marble weathers to a sand or sandy clay to depths locally in excess of 100 feet. The yields of 55 wells ending in the marble range from less than 1 to 80 gallons per minute and average about 19 gallons per minute. The average depth of wills in the marble is about 210 feet. The yields of wells are related to the topographic situation. The best wells are in the valleys and the poorest are on hilltops.

The total use of ground water in the area is about 4 million gallons per day, most of which is used for domestic or agricultural purposes. There are no public supplies (municipal) from a ground-water source in the Piedmont section of either county, although formerly several communities had public water supplies derived from wells.

The chemical character of the ground water is generally satisfactory for most uses, as shown by 61 chemical analyses of water from wells or springs. Dissolved solids in 51 samples average 105 parts per million. The hardness in 60 samples averages 59 parts per million. The hardest water is obtained from wells or springs in marble. The iron content is generally low, but it ranges from 0 to 3.5 parts per million.

Additional ground-water supplies are available for rural and domestic use, but supplies for industrial and irrigation use are limited to an estimated maximum of a few hundred thousand gallons a day.

Source: Dingman, R. J. and Ferguson, H. F. 1956. The Ground-Water Resources of the Piedmont part, in The Water Resources in Baltimore and Harford Counties. Maryland Department of Geology, Mines and Water Resources. Bulletin 17. pp. 1-128

APPENDIX H

THE WATER RESOURCES OF CECIL, KENT AND QUEEN ANNES COUNTIES

by

Robert M. Overbeck and Turbit H. Slaughter

Cecil, Kent, and Queen Annes Counties have a land area of 1,009 square miles and their permanent population was 61,612 in 1950. Ground-water data were obtained from about 2,100 wells and 26 springs, compiled from the reports of drillers and of well owners.

The mean annual precipitation is about 43 inches. The average daily consumption of ground water in the area is estimated to be about 4,000,000 gallons. The water is used almost entirely for farm and domestic purposes.

The northern part of Cecil County lies in the Piedmont physiographic province and is underlain by igneous and metamorphic rocks of Precambrian and Paleozoic (?) age, consisting of granodiorite, gabbro, metadacite, serpentine, gneiss, chlorite, and mica schist. Ground water occurs chiefly under watertable conditions in fractures in the hard unweathered rock and in pores and permeable zones in the weathered rock. The source of nearly all the ground water is precipitation. About half the wells in the Piedmont are dug wells. Of the drilled wells many are less than 100 feet deep. The average yield of all wells is about 11 gallons a minute. The quality of the water is generally good, although ground water from the serpentine area is hard. At a few places iron is present in noticeable amounts. Wells commonly provide sufficient water for domestic or farm use, but large yields cannot be expected from the crystalline rocks. An aquifer test in the granodiorite showed a coefficient of transmissibility of 14,000 gallons per day per foot and a coefficient of storage of 0.003.

Kent and Queen Annes Counties and the southern portion of Cecil County are in the Coastal Plain. The Coastal Plain deposits, consisting of sand, clay, sandy clay and silt, greensand, and marls, rest on the southeastward sloping surface of the crystalline rocks. The deposits form a wedge-shaped mass of material which ranges in thickness from a few inches in Cecil County to 2,500 feet in Queen Annes County. In Cecil County their maximum thickness is estimated to be 1,700 feet, in Kent County their thickness ranges from 900 to 2,200 feet, and in Queen Annes County from 1,500 to 2,500 feet.

The Coastal Plain deposits are Cretaceous, Tertiary, and Quaternary in age. The Cretaceous rocks are of continental and marine origin; the Tertiary rocks of marine origin; and the Quaternary rocks of fluviatile and marine origin. The formations of continental origin--Patuxent, Patapsco, Raritan, and Magothy--are characterized by light-colored, buff to red, sand, silt, and clay. The sand beds are linticular and strongly crossbedded. The Cretaceous and Tertiary marine formations--Matawan, Monmouth, Aquia, and Calvert--are characterized by dark-colored clay, silt, greensand, and marl. The Quaternary deposits consist of crossbedded sand, gravel, clay, and silt.

The most extensively used aquifers are in the Pleistocene deposits (38 per cent of the wells), but the total amount of water withdrawn from these deposits is relatively small. The greatest quantity of water is probably being taken from the Aquia greensand (19 per cent of the wells). The Patapsco, Raritan, Magothy, Matawan, and Monmouth formations locally are important aquifers. The Calvert formation is relatively unimportant as a source of water (1 per cent of the wells).

Wells ending in the Patuxent formation have an average yield of 16 gpm; in the Patapsco, 40 gpm; in the Raritan, 35 gpm; in the Magothy, 30 gpm; in the Matawan, 38 gpm; in the Monmouth, 40 gpm; in the Aquia, 27 gpm; in the Calvert, 53 gpm; in the Wicomico, 43 gpm; and in the Talbot formation, 24 gpm.

Aquifer tests on the Patapsco formation at Elkton showed coefficients of transmissibility of 5,500 to 24,000 gallons per day per foot. A test on the Magothy at Cecilton indicated a transmissibility coefficient of 25,000 gallons per day. Tests on the Monmouth formation at Rock Hall, Massey, and Kennedyville indicate transmissibility coefficients of 4,600, 5,700 and 4,900 gallons per day respectively. Storage coefficients from these tests range from 0.0000003 to 0.0004. Tests on the Aquia greensand at Massey and Queenstown indicate a coefficient of transmissibility of 4,100 and 35,000, respectively. Storage coefficients were 0.0005 and 0.00025, respectively. At Chestertown an aquifer test on the Aquia greensand failed to give a satisfactory result for the value of T and S due probably to indeterminate boundary conditions in the aquifer. An aquifer test in the Wicomico formation at Price showed a coefficient of transmissibility of 30,000 gpd per ft. and a storage coefficient of 0.0003.

The quality of ground water in the Coastal Plain area is generally good. The content of dissolved solids is low, and pH lies within a narrow range of the neutral point. Water from several aquifers, however, contains iron in sufficient quantity to cause trouble for the domestic user. Ground water from the Patapsco, Raritan, Magothy, Matawan, and Monmouth formations is generally rather high in iron. Water from the Matawan, Monmouth, and, in southern Queen Annes County, from the Aquia greensand, is hard. At places ground water from the Wicomico formation is soft and free of iron.

The average temperature of the ground water is approximately 58°.

Three general classes of wells are used, drilled, dug, and driven. Of the approximately 2,100 wells inventoried, drilled wells constitute about 53 per cent, and dug and driven wells about 47 per cent.

Fluctuations of the water table since 1949 were determined by periodic measurements in six observation wells. These showed an annual fluctuation in response to recharge to and discharge from the ground-water reservoirs caused by changes in the rate and amount of precipitation and by other factors. Fluctuations of the water level were observed in two artesian wells for a shorter period of time. No significant decline in water levels was observed. A comparison of the static water levels at Rising Sun, Massey, Millington, and Stevensville with those measured more than 40 years ago indicates no significant change in static levels in the water table or in artesian aquifers in those areas.

A rough estimate of the amount of ground water in storage in the sediments underlying the three counties is 31 trillion gallons. The amount of water recharging the deposits is about 0.4 to 0.6 million gallons per square mile per day. The present consumption of ground water is about 4,000 gallons per square mile per day, or only about 1 per cent of the estimated ground-water recharge.

Source: Overbeck, Robert M. and Slaughter, Turbit H. 1958. Ground-Water Resources in The Water Resources of Cecil, Kent, and Queen Annes Counties. Maryland Department of Geology, Mines and Water Resources. pp. 1-382.